SUGARBEET RESEARCH

2005 REPORT

FOREWARD

SUGARBEET RESEARCH is an annual compilation of progress reports concerning research by U.S. Department of Agriculture, Agricultural Research Service investigators and other cooperators who are engaged in sugarbeet research. The report was assembled and produced at the expense of the Beet Sugar Development Foundation and is for the sole use of its members and the cooperators. Much of the data has not been sufficiently confirmed to justify general release and interpretations may be modified with additional experimentation. This report is not intended for publication and should not be used for cited reference nor quoted in publicity or advertising. Reproduction of any portion of the material contained herein will not be permitted without the specific consent of the contributors and the Beet Sugar Development Foundation.

The report presents results of investigations strengthened by contributions received under Cooperative Agreement between the USDA Agricultural Research Service and the Beet Sugar Development Foundation, along with the California Beet Growers Association, the Western Joint Research Committee, and the Sugarbeet and Education Board of Minnesota and North Dakota.

Trade names occur in this report solely to provide specific information and do not signify endorsement by the U.S. Department of Agriculture, the Beet Sugar Development Foundation or any of the cooperating organizations.

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SUGARBEET RESEARCH
USDA-ARS – AGRICULTURAL RESEARCH STATION
SALINAS, CALIFORNIA

2005 REPORT

SECTION A

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This research was supported in part by funds provided through the Beet Sugar Development Foundation (Projects 211, 215, 221 and 261), the California Beet Growers Association and the California Industry Research Committee.

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ABSTRACTS OF PAPERS PUBLISHED OR APPROVED FOR PUBLICATION, 2005

Adkins, S., Wintermantel, W.M., Momol, T., and Polston, J.E. 2006. Virus Diseases. In: Tomato Health Management. APS Press, St. Paul, MN. (Book chapter).

Biancardi, E. and Lewellen, R.T. 2005. Downy mildew. pp. 92-93. In (eds. E. Biancardi, L.G. Campbell, G.N. Skaracis, & M. DeBiaggi) Genetics and Breeding of Sugar Beet. Science Publishers, Inc. Enfield, NH, USA.

Downy mildew, caused by Peronospora schachtii (farinosa), attacks newly developed leaves in rainy or cool climates. Severe damage is quite frequent in northern Europe in both sugar and seed crops. Crombie and O'Connor (1960) observed a correlation between ploidy level and disease severity. In particular, tetraploid genotypes appeared more resistant than 3n and 2n genotypes. Campbell and Russell (1964) listed six distinct independent resistance mechanisms, of which the most important is the hypersensitive reaction of host cells. In contrast to the hypersensitive response, the other factors are quantitative and relative severity is influenced by interactions with the environment.

Friesen, T.L., Weiland, J.J., Aasheim, M.L., Hunger, S., Borchard, D.C., and Lewellen, R.T. 2006. Identification of a SCAR marker associated with *Bm*, the beet mosaic virus resistance gene, on chromosome 1 of sugar beet. Plant Breeding 125: 167-172.

Beet Mosaic Virus (*BtMV*) is an aphid transmitted, viral disease of beet found worldwide. The *Bm* gene, a resistance gene effective against *BtMV*, was identified in the sugar beet line B500 and backcrossed into a C37 background to produce line C719. Three populations were developed from the cross of line C719 with the susceptible line C37 with the intent of developing markers for use in marker-assisted selection. The F_2 progeny of three crosses were score for resistance. Two of the three populations conformed to a 3:1 ratio, indicating a single gene trail. Sequence characterized amplified region (SCAR) markers were developed by using bulked segregant analysis combined with random amplified polymorphic DNA type markers. The markers showed close association to the *Bm* resistance gene and were effective in all three populations. The A_t allele for genetic male sterility also was found to be associated with *Bm* and the SCAR marker. Development of a single-nucleotide polymorphism marker from the SCAR sequence was used to validate linkage to chromosome 1 using separate mapping populations. This marker will be useful for the introgression of the *Bm* gene into germplasm.

Hayes, Ryan J., Wintermantel, W.M., Nicely, P. A., and Ryder, E.J. 2006. Host resistance to *Mirafiori lettuce big-vein virus* and *Lettuce big-vein associated virus* and virus sequence diversity and frequency in California. Plant Disease 90: 233-239.

Big vein is an economically damaging disease of lettuce (*Lactuca sativa* L.) caused by the *Olpidium brassicae* vectored *Mirafiori lettuce big-vein virus* (MLBVV). *Lettuce big-vein associated virus* (LBVaV) is also frequently identified in symptomatic plants, but no causal relationship has been demonstrated. Although big vein is a perennial problem in the US, the extent of MLBVV and LBVaV infection and diversity is unknown. Lettuce cultivars partially

resistant to big vein reduce losses, but do not eliminate disease. While *L. virosa* L. does not develop big vein symptoms, it has not been tested for infection with MLBVV or LBVaV. Lettuce cultivars Great Lakes 65, Pavane, Margarita, and *L. virosa* accession IVT280 were evaluated for big vein incidence and virus infection in inoculated greenhouse trials. Additional lettuce samples were collected from field sites in California, classified for symptom severity and evaluated for virus infection. Reverse transcription-polymerase chain reaction and nucleotide sequencing were used to determine infection with MLBVV and LBVaV, and sequence diversity among viral isolates, respectively. Infections with MLBVV and MLBVV/LBVaV were dependent on big vein symptom expression in California production areas and isolates were closely related to those found in Europe and Japan. Partial big vein resistance was identified in Margarita and Pavane; however, MLBVV infection was found in asymptomatic plants. *L. virosa* IVT280 remained symptomless and virus free, suggesting that it is immune to MLBVV and LBVaV.

Lewellen, R.T. 2005. Evaluation of cultivars of sugarbeet with cyst nematode resistance in California. The California Sugar Beet 2004 Annual Report. p. 10-11.

See pages A40-A43, 2004 Sugarbeet Research Report.

Lewellen, R.T. 2006. Registration of CN12 and CN72 sugarbeet germplasm populations with resistance to cyst nematode. Crop Sci. 46: (in press).

Sugarbeet (*Beta vulgaris* L.) germplasm lines CN12 (Reg. no. GP-256, PI636338) and CN72 (Reg. no. GP-257, PI636339) were developed by the USDA-ARS in cooperation with the Beet Sugar Development Foundation (BSDF) and the California Beet Growers Association. They were released in 2005.

CN12 and CN72 are multigerm (*MM*), self-fertile (*S^f^*), genetic-male-sterile (*A_:aa*) facilitated, random-mated populations that segregate for resistance to sugarbeet cyst nematode (SBCN) (*Heterodera schachtii* Schmidt). Based upon greenhouse tests of individual plants, both populations have about 40% of their plants that are moderately to highly resistant to SBCN. The resistance factors were derived from different wild beet (*Beta vulgaris* subsp. *maritima*) accessions but these accessions may have initially come from the same or similar source. Inheritance of resistance has yet to be determined, but empirical results and performance of selections, progeny lines, and hybrids suggest that resistance is highly heritable, dominant, and due to one or a few genetic factors. Resistance may be similar to that reported from *B. vulgaris* subsp. *maritima* that conditions partial resistance (Heijbroek, 1977). Resistance is not from the wide crosses involving *B. procumbens* Chr. Sm. (Savitsky, 1975). Although considered to be partial resistance, this resistance gives a high level of protection against economic losses in field tests (Lewellen & Pakish, 2005).

CN12 is a multigerm, self-fertile population that segregates for genetic male sterility. CN12 segregates for resistance to sugarbeet cyst nematode, powdery mildew (*Erysiphe polygoni* DC.) (syn. *E. betae* Weltzien) conditioned by *Pm* (Lewellen & Schrandt, 2001), and rhizomania (*Beet necrotic yellow vein virus*) conditioned by *Rz1*. Most, if not all, of the annualism (*B*) of the wild beet ancestry has been eliminated and CN12 has moderate nonbolting tendency. It has moderate resistance to *Curly top virus*, virus yellows (*Beet chlorosis virus* and *Beet yellows virus*), and

sugarbeet *Erwinia* (*E. carotovora betavasculorum* Thomson et al.). Its developmental lines have shown good yield performance particularly under natural infection with SBCN and rhizomania. The precise frequency of resistance to SBCN has not been determined nor has the efficacy of this resistance been fully characterized in field and greenhouse tests.

Theoretically, CN12 is 12.5% wild beet (WB) with about equal proportions of WB97 (PI546394) and WB242 (PI546413). WB97 and WB242 were each crossed to breeding line C54 (PI590802). In 1991, these F_1's were combined and crossed to genetic-male-sterile plants from population 0747 (PI590762). Population 0747 is similar to C37 (PI590715) and one of the progenitors of population C931 (PI636340). Plants within the F_1BC_1 generation were selected under field conditions for resistance to powdery mildew and increased in bulk to produce line P202. Line P202 was grown in the field in 1993 under natural powdery mildew and SBCN conditions. When individual plants were examined and selected, it was observed that in addition to segregating for reaction to powdery mildew (*Pm_:pmpm*), some root systems were heavily infested with SBCN cysts and a few intermingled roots were completely free of visible cysts. The selected plants were divided into two groups, one that was free of cysts to become P402NR and one that had high resistance only to powdery mildew to become P402. P402 and P402NR were crossed to population C931.

Individual F_1BC_2 families were grown under naturally infected rhizomania and powdery mildew conditions at Salinas in 1997. Plants dually resistant to rhizomania and powdery mildew from both sets of families were combined and increased in bulk to produce P812. A second cycle of mass selection for resistance to powdery mildew, rhizomania, freedom from bolting, and agronomic type was done to produce P912. Up to line P912, selected plants had been increased in bulk in isolation and could have produced various combinations of sib matings and selfs to produce mixtures of S_o, S_1, and S_2 plants. P912 would have likely segregated for self-fertility, genetic male sterility, powdery mildew, rhizomania, hypocotyl color (*R:rr*), etc. Population P912 was selected by mass selection two additional times in the field at Salinas under natural rhizomania, SBCN, and powdery mildew conditions to produce lines called N112 and then N312 in 2003. In addition to resistance to diseases, roots were selected on the basis of agronomic type, size, and sugar concentration. Selection for resistance was done visually at harvest with only plants resistant to all three diseases selected, but it is likely that escapes, particularly for SBCN, occurred under these field conditions.

In addition to mother root selection and bulk increase, individual plants from population P912 were selfed to produce N112-# progenies. These selfed progeny families were evaluated for performance at Salinas and Brawley under both diseased and nondiseased conditions. At Brawley, the progeny test was under severe SBCN conditions. Based upon line performance in these tests, individual stecklings from within the selected progenies were bulked and increased by selfing to produce a second cycle of selfed progeny families called N212-#. The second cycle progenies were also evaluated at Brawley and Salinas in a series of tests that evaluated performance, bolting tendency, and disease resistance. From 48-second cycle families, stecklings from 14 families were selected and bulked. This bulk was combined with stecklings from N312 in approximately equal proportions and recombined through the segregating genetic male steriles to produce population N412 released as CN12.

CN72 is a multigerm, self-fertile population that segregates for genetic male sterility. It has approximately 25% wild beet germplasm. CN72 segregates for resistance to SBCN and

rhizomania conditioned by *Rz1*. Most of the annualism of the wild beet ancestry has been eliminated. The precise frequency of resistance to SBCN has not been determined. It is not known if the resistance in CN72 is identical to that in CN12. The wild beet source of resistance to SBCN was a Salinas accession from Europe that had been reported to be tolerant/resistant to SBCN. The increase of this accession at Salinas in 1994 was called N499 (PI599349). In 1997, plants from N499 were crossed to genetic male sterile plants from population C931. F_1 plants selected for resistance to rhizomania were backcrossed to C931 to produce line N972. N972 was developed in parallel with P912 (see above). The same criteria of selection were used except N972 does not segregate for *Pm* that conditions high powdery mildew resistance. Identical kinds of lines and selfed progenies were produced. After two cycles of mass or bulk selection and increases, lines N172 and then N372 were produced. Similarly, after two cycles of selfed family selection from N972, progeny lines N272-#s were produced. Because N972 would have segregated for genetic male sterility and self-fertility and pollination was not controlled within the isolation chambers, N372 could have been composed of S_o, S_1, and/or S_2 plants. Stecklings of N372 and from 10 selected families out of 24 of N272-# S2's were combined in approximately equal numbers and recombined through the genetic male steriles to produce N472, released as CN72.

CN12 and CN72 are being released as possible sources of resistance to SBCN in enhanced backgrounds. Selections from CN12 may lead to potential parental lines but CN72 retains too many wild beet influences for this purpose. Both lines will likely need to be further backcrossed to advanced sugarbeet parental lines. These lines may be useful for biological and agronomic tests to evaluate the efficacy of these sources of SBCN resistance and to establish progenies to search for molecular markers.

Lewellen, R.T. 2006. Registration of C931, C941, CR11, and CZ25/2 self-fertile, genetic-male-sterile facilitated, random-mated, sugarbeet germplasm populations. Crop Sci. 46: (in press).

Sugarbeet (*Beta vulgaris* L.) germplasm lines C931 (Reg. no. GP-252, PI636340), C941 (Reg. no. GP-253, PI636341), CR11 (Reg. no. GP-255, PI636343), and CZ25/2 (Reg. no. GP-254, PI636342) were developed by the USDA-ARS in cooperation with the Beet Sugar Development Foundation (BSDF) and the California Beet Growers Association. They were released in 2005.

C931, C941, CR11, and CZ25/2 are multigerm (*MM*), self-fertile (S^f), genetic-male-sterile (*A_:aa*) facilitated, random-mated populations. These populations were developed in the population improvement program at Salinas. Very succinctly, these populations have the following relationships and attributes:

C931 = base *MM*, S^f, *A:aa*, *Rz1*, curly-top resistant population similar to C37/C46;
C941 = C931 x virus yellows resistant breeding lines;
CR11 = C931 x Cercospora leaf spot resistant breeding lines; and
CZ25/2 = C931 x high sucrose concentration breeding lines.

C931 has been under development for about 35 years (Lewellen, et al., 1978b). In its various developmental phases, it has been commonly used in the breeding and genetics research program at Salinas as a basic breeding population for population improvement and for selecting traits for

productivity and disease resistance. C931 has the agronomic characteristics of a moderately broad, open-pollinated (OP, self-sterile) line with disease adaptation to the far western USA. In some breeding, selection, genetic, and germplasm improvement programs, there is a distinct advantage to be able to create easily selfed progeny families with large amounts of seed that can be recombined. C931 can be maintained by bulk increases or like an OP line by harvesting seed from the male-sterile segregates. The combination of self-compatibility (S^f) and genetic male-sterility allows complete flexibility in the choice of progeny and testcross families to be generated. The pedigree and development of C931 are complex and have involved both mass or mother root selection and selfed-progeny evaluation and selection. The primary source of germplasm was from C918 (PI578079) released in 1993. Thus much of the germplasm base comes from C37 (PI590715) (Lewellen et al., 1985b) and C46 (PI590757) (Lewellen et al., 1985a). Smaller portions are from C31/6 (PI590799) (Lewellen et al., 1978a) type sources and wild *Beta vulgaris* subsp. *maritima*. It is estimated that about 1-2% of the germplasm would have come from wild beet through C51 (PI593694) (Lewellen, 2000b).

From C918, population C931 has the *Rz1* allele that conditions resistance to rhizomania caused by *Beet necrotic yellow vein virus*. C931 is moderately resistant to *Beet curly top virus*, virus yellows caused by *Beet chlorosis virus* and *Beet yellows virus*, powdery mildew caused by Erysiphe *polygoni* DC. (syn. *E. betae* Weltzien), sugarbeet *Erwinia* (*E. carotovora betavasculorum* Thomson, et al.), and bolting. From C918, two cycles of S_1 progeny recurrent selection interspersed with three cycles of mass selection have been made. Germplasm from C31/6 and C51 was introduced from selected S_1 families of which C918 was a major component. One cycle of mass selection was for combined resistance to rhizomania, *Erwinia*, and slow mildewing and for sucrose concentration. The other two cycles were for resistance to rhizomania in 3-4 month old plants. For the two cycles of S_1 progeny evaluation and selection, stecklings were randomly selected and selfed. Multiple progeny tests were run at Salinas under conditions to promote moderate bolting, under nondiseased conditions, and under rhizomania and powdery mildew conditions. Based upon nonbolting tendency, sugar concentration and yield, and resistance to rhizomania and powdery mildew, 5-10% selection intensity was used and stecklings of the selected families were recombined through the segregating genetic male steriles. Following the final cycles of selection, two additional cycles of resynthesis were made to produce population 4931 released as C931. C931 has been tested as 8931, 9931, 0931, 1931, 2931, and 3931. C931 is an advanced sugarbeet population. It could be useful as a direct source for selecting improved parental lines. More likely, it may be most useful like it has been used in the Salinas program as an advanced population for introgression of useful traits and developing other populations and breeding lines.

C941 was developed from crosses between developmental lines of C931 and breeding lines C76-89-5 (PI593698) (Lewellen, 1998) and C69 (PI599341) (Lewellen 2000a). A selection and improvement program was similar to that used for C931 but greater emphasis was placed upon selecting for improved resistance to virus yellows based on virus yellows inoculated progeny tests. Because C941 is about 50% C76-89-5 and C69, its curly top resistance is less but sucrose concentration and sugar yield combining ability are slightly better. C941 has been developed and tested as 9941, 0941, 1941, 2941, and 3941. Following two cycles of resynthesis through genetic-male-sterile segregates, population 4941 was produced and released as C941.

CR11 was developed from crosses between developmental lines of C931 and CR09 (PI593692) and CR10 (PI593693). CR09 and CR10 have moderate resistance to Cercospora leaf spot

(caused by *C. beticola* Sacc.) derived from two 1997 Italian accessions and are 25% modern Italian germplasm. CR11 then will have about 12.5% germplasm from these Italian lines and about 87.5% germplasm similar to C931. Following one cycle of recombination, S_1 progenies were generated and evaluated for bolting tendency and resistance to rhizomania and *Cercospora* leaf spot. Stecklings from the selected progenies were bulked and recombined. From the recombination isolation plot, seed from individual male-sterile plants was harvested separately to create half-sib progenies. These half-sib lines were evaluated for bolting tendency, sugar concentration and yield, and resistance to rhizomania and *Cercospora* leaf spot. About 12% of the families were selected and stecklings from these lines were recombined to produce population CR311. Plants of CR311 were mass selected for resistance to rhizomania and resynthesized to produce population CR411 released as CR11. CR11 has been evaluated as CR011, CR111, CR211, and CR311. CR11 should have traits similar to C931 but be substantially improved for resistance to *Cercospora*. In tests at Salinas, CA, Fort Collins, CO, and Shakopee, MN, its reaction to *Cercospora* was one grade superior to 'Monohikari' check and equal to or better than breeding line SP6822-0. Individual progeny lines expressed even better resistance than the level of the population.

CZ25/2 represents additional population improvement in population CZ25 (PI599343) released in 1997. CZ25 and CZ25/2 have about 37% of their germplasm from high sugar, 2x = 18 lines accessed from Poland in 1988. Following one cycle of mass selection for sugar concentration and combined resistance to rhizomania and *Erwinia* from CZ25, individual plants were selfed to produce S_1 progenies. Progeny tests were run under bolting induction conditions and under nondiseased and rhizomania conditions. Stecklings from the selected S_1 lines were recombined with seed from each individual male-sterile plant in the pollination isolation plot harvested separately. These half-sib families were progeny tested for bolting tendency and sugar concentration and yield under both nondiseased and rhizomania conditions. Based upon nonbolting tendency and sugar concentration and yield, stecklings from approximately 12% of these progeny lines were resynthesized to produce population Z325. Z325 was reselected for resistance to rhizomania and again resynthesized to produce population Z425 released as CZ25/2. CZ25/2 has been evaluated as populations Z125, Z225, and Z325. CZ25/2 has improved sugar concentration compared to C931 and based upon extracted progeny lines, selection for high sucrose in combination with fair to moderate resistance to curly top and virus yellows is possible.

Populations C931, C941, CR11, and CZ25/2 should be useful as sources of combined disease resistance with good potential for productivity. Direct extraction of potential parental lines may be possible.

Lewellen, R.T. and Biancardi, E. 2005. Beet mosaic. pp. 79-80. In (eds. E. Biancardi, L.G. Campbell, G.N. Skaracis, & M. DeBiaggi) Genetics and Breeding of Sugar Beet. Science Publishers Inc. Enfield, NH, USA.

Beet mosaic virus (BMV), transmitted non-persistently by the green peach aphid Myzus persica, is widespread especially in temperate regions where sugar beet is grown as a winter crop or overwintered for seed production. BMV is often associated with beet yellows virus (BYV). The pathogenic effects of the two viruses are additive but the damage caused by BMV is small compared to that caused by BYV. The infection appears as small yellow spots on the younger

leaves that develop later on to pale green-yellow mottling. A 20% root yield reduction was observed in a very severe attack of BMV.

Lewellen, R.T. and Biancardi, E. 2005. Southern Sclerotium root rot. p. 100. In (eds. E. Biancardi, L.G. Campbell, G.N. Skaracis, & M. DeBiaggi) Genetics and Breeding of Sugar Beet. Science Publishers, Inc. Enfield, NH, USA. (Book chapter).

Southern Sclerotium root rot, caused by the fungus Sclerotium rolfsii, is a problem in warm beet-growing areas, especially when sugar beet is grown as a winter crop. The effects of the disease on the plants are devastating: a blackish rot develops rapidly in the taproots, which become completely covered by thick strands of white mycelium. Several dark brown spherical sclerotia subsequently appear in this cottony layer. The disease can develop rapidly in piled beets, causing severe postharvest storage losses, and subsequently problems in processing (slicing, diffusion, etc.). In some production areas, infection by Sclerotium may occur prior to seedling emergence. Attempts to control the disease with chemicals, crop rotation, or biological control agents have not been successful. As of now, no effective control method is available. Heavy applications of nitrogen fertilizer appear to reduce the damage caused by southern Sclerotium root rot.

Lewellen, R.T. and Biancardi, E. 2005. Yellow wilt. pp. 87-88. In (eds. E. Biancardi, L.G. Campbell, G.N. Skaracis, & M. DeBiaggi) Genetics and Breeding of Sugar Beet. Science Publishers, Inc. Enfield, NH, USA.

Yellow wilt is a serious destructive sugar beet disease that occurs only in Argentina and Chile. Symptoms include yellowing and wilting of the larvae, resulting in the death of infected plants, especially when accompanied by drought and high temperatures. Yellow wilt is caused by a rickettsia-like organism transmitted by a leafhopper, Paratanus exitiosus, and two species of dodder. Gaskill and Ehrenfeld (1975) observed a range in disease severity among 381 varieties and breeding lines of European and American origin. Efficient screening and breeding programs must have disease nurseries or screening procedures that guarantee high percentages of infected plants. Mother beets are selected in both the yellowing and subsequent wilting phase.

Success in breeding for resistance was initially hampered by frequency of escapes in the disease nurseries and difficulties in producing seed on selected plants that were resistant, but not immune. Satisfactory amounts of seed were obtained by repeatedly spraying the flowering plants with antibiotics. Three sea beet introductions displayed a relatively high resistance to yellow wilt, suggesting sea beet is a potential source of resistance genes. As of now, no variety with appreciable resistance to yellow wilt has been identified.

Lewellen, R.T. and Pakish, L.M. 2005. Performance of sugarbeet cyst nematode resistant cultivars and a search for sources of resistance. Amer. Soc. Sugar Beet Techn., March 2-5, 2005, Palm Springs, CA. p. 122-123.

Sugarbeet cyst nematode (SBCN) is a major problem of sugarbeet worldwide. Sugarbeet hybrids and lines with resistance to SBCN were evaluated in field trials at Brawley and Salinas, CA.

These trials were under nondiseased and SBCN/rhizomania conditions. Resistance to SBCN was derived from both Beta procumbens and other sources. At Brawley under high SBCN populations and low to moderate rhizomania, hybrids with SBCN resistance had sugar yields from 170 to 230% higher than the SBCN susceptible-resistant commercial checks. SBCN eggs + larvae counts were about five times higher from the commercial checks as compared to counts from either source of SBCN resistance. Germplasm lines developed at Salinas and released as C927-4, CN12, CN72, and others showed promise as sources of resistance to SBCN. Progeny families are being evaluated and screened in greenhouse and field tests for high levels of resistance.

Liu, H. Y., Sears, J. L., Lewellen, R. T. 2005. Biological and molecular analysis of *Beet necrotic yellow vein virus* isolates that overcome the resistance genes. J. Sugar Beet Research 42:59-60, 2005.

Rhizomania is an important virus disease of sugar beet. The disease is caused by *Beet necrotic yellow vein virus* (BNYVV) and vectored by the plasmodiophorid *Polymyxa betae*. The disease can only be controlled effectively by the use of resistant cultivars. During the 2002-2003, several sugar beet fields with cultivars partially resistant to BNYVV grown in the Imperial Valley of California were observed with severe rhizomania symptoms, suggesting that resistance conditioned by *Rz1* allele had been compromised. Soil testing with sugar beet baiting plants followed by ELISA tests was used to diagnose virus infection. Resistant varieties grown in BNYVV-infested soil from Salinas, CA were ELISA negative. In contrast, when grown in BNYVV-infested soil collected from the Imperial Valley, CA all resistant varieties became infected and tested positive by ELISA. Based on host reaction, distinct BNYVV isolates have been identified from Imperial Valley soil (IV-BNYVV) by single local lesion isolation. These isolates do not contain RNA-5 as determined by RT-PCR. From the banding patterns of single-strand conformation polymorphism analyses we concluded that the resistance-breaking BNYVV isolates from Imperial Valley had likely evolved from the original existing A-type. The pathogenicity of IV-BNYVV isolates was studied. PCR products of RNA2 coat protein gene and P-25 protein (encoded by BNYVV-RNA-3, involved in symptom expression) of IV-BNYVV isolates were sequenced. Sequence alignments revealed only minor amino acid changes compared to the existing A-type of California BNYVV isolates.

Liu, H. Y., Sears, J. L., Lewellen, R. T. 2005. Etiology and pathogenicity studies of resistance-breaking isolates of *Beet necrotic yellow vein virus*. Abstract of IX International Plant Virus Epidemiology Symposium. Page 96, April 4-7, Lima, Peru.

Rhizomania is one of the most economically important diseases of sugar beet and is widely distributed in most sugar beet growing areas worldwide. The disease is caused by *Beet necrotic yellow vein virus* (BNYVV) and vectored by the soil-borne fungus *Polymyxa betae*. The disease can only be controlled effectively by the use of resistant cultivars. During 2002 and 2003, several sugar beet fields with cultivars partially resistant to BNYVV grown in the Imperial Valley of California were observed with severe rhizomania symptoms, suggesting that partially resistant sugar beet cultivars with *Rz1* allele developed against this devastating disease seem to be compromised. Based on host reaction, distinct BNYVV isolates have been identified from Imperial Valley soil (IV-BNYVV) by single local lesion isolation. These isolates do not contain RNA-5 as determined by RT-PCR. From the banding patterns of single-strand conformation

polymorphism analyses we concluded that the resistance-breaking BNYVV isolates from Imperial Valley had likely evolved from the original existing A-type. The pathogenicity of IV-BNYVV isolates was studied. PCR products of coat protein gene from RNA-2 and P-25 protein (encoded by BNYVV-RNA-3, involved in symptom expression) of IV-BNYVV isolates were sequenced. Sequence alignments revealed only minor amino acid changes compared to the existing A-type of California BNYVV isolates.

Liu, H.Y., Sears, J.L., and Lewellen, R.T. 2005. Occurrence of resistance-breaking *Beet necrotic yellows vein virus* of sugar beet. Plant Dis. 89: 464-468.

Rhizomania is an important virus disease of sugar beet and is caused by *Beet necrotic yellow vein virus* (BNYVV). During 2002–03, several sugar beet fields with cultivars partially resistant to BNYVV grown in the Imperial Valley of California were observed with severe rhizomania symptoms, suggesting that resistance conditioned by *Rz1* had been compromised. Soil testing with sugar beet baiting plants followed by enzyme-linked immunosorbent assay (ELISA) was used to diagnose virus infection. Resistant varieties grown in BNYVV-infested soil from Salinas, CA, were ELISA-negative. In contrast, when grown in BNYVV-infested soil collected from the Imperial Valley, CA, all resistant varieties became infected and tested positive by ELISA. Based on host reaction, eight distinct BNYVV isolates have been identified from Imperial Valley soil (IV-BNYVV) by single local lesion isolation. Reverse transcription–polymerase chain reaction (RT-PCR) assays showed that the eight IV-BNYVV isolates did not contain RNA-5. Single strand conformation polymorphism banding patterns for the IV-BNYVV isolates were identical to A-type and different from P-type. Sequence alignments of PCR products from BNYVV RNA-1 near the 3′ end of IV-BNYVV isolates revealed that both IV-BNYVV and Salinas BNYVV isolates were similar to A-type and different from B-type. Our results suggest that the resistance-breaking BNYVV isolates from Imperial Valley likely evolved from existing A-type isolates.

McCreight, J. D., Liu, H.-Y., and Turini, T. 2005. Resistance to *Cucurbit leaf crumple virus* in melon. Hortscience 40 (4): 1108-1109.

Cucurbit leaf crumple geminivirus (CuLCrV) is transmitted by sweet potato whitefly (*Bemisia tabaci*) biotype B and occurs on cucurbits in Arizona, California, Texas, and Mexico. The virus is identical to *Cucurbit leaf curl virus*, and their symptoms are similar to *Squash leaf curl virus* on melon (*Cucumis melo* L.) Melon has been reported to be either susceptible to CuLCrV, or to have the ability to recover from infection in response to natural or controlled inoculation. Twenty-seven (verify) melon cultigens were evaluated in field and greenhouse tests for reaction to CuLCrV. Although most (19) of the cultigens exhibited CuLCrV symptoms in greenhouse tests and symptoms abated, they remained positive for the virus. Eight cultigens were resistant in greenhouse tests. PI 313970, melon from India and the most extensively tested accession in this group of 27 cultigens, was highly resistant in field and greenhouse tests. Leaves of PI 313970 occasionally exhibited small, yellow foecks in response to inoculation in the greenhouse or field; a few of those plants were positive for the virus.

Panella, L. and Lewellen, R.T. 2005. Fusarium yellows. pp. 93-95. In (eds. E. Biancardi, L.G. Campbell, G.N. Skaracis, & M. DeBiaggi) Genetics and Breeding of Sugar Beet. Science Publishers, Inc. Enfield, NH, USA.

See Fort Collins section for abstract.

Panella, L. and Lewellen, R.T. 2005. Plant introduction and genetic diversity. pp. 34-38. In (eds. E. Biancardi, L.G. Campbell, G.N. Skaracis, & M. DeBiaggi) Genetics and Breeding of Sugar Beet. Science Publishers, Inc. Enfield, NH, USA.

See Fort Collins section for abstract.

Panella, L. and Lewellen, R.T. 2005. Registration of FC201, a heterogeneous, disease-resistant, monogerm, O-type sugarbeet populations. Crop Sci. 45:1169-1170.

See Fort Collins section for abstract.

Panella, L. and Lewellen, R.T. 2005. Registration of FC301, monogerm, O-type sugarbeet populations with multiple disease resistance. Crop Sci. 45:2666-2667.

See Fort Collins section for abstract.

Panella, L. and Lewellen, R.T. 2006. Broadening the genetic base of sugar beet: Introgression from wild relatives. Euphytica (accepted 02/2006).

See Fort Collins section for abstract.

Rush, C.M., Liu, H.Y., Lewellen, R.T., and Acosta-Leal, R. 2006. The continuing saga of rhizomania of sugar beet in the United States. Plant Disease 90:4-15.

Rhizomania caused by *Beet necrotic yellow vein virus* (BNYVV) is the most important soil-borne virus disease of sugar beet worldwide. Since 1984 when discovered, the gene *Rz1* has provided a high level of resistance. In 2002 in the Imperial Valley of California, cultivars with *Rz1* resistance began to show severe symptoms of rhizomania. In subsequent years, these resistance breaking isolates occurred in additional fields and threaten to completely defeat the *Rz1* resistance. This feature article in PLANT DISEASE on these resistance breaking strains in sugar beet combines a summation of rhizomania disease and published research up to present. It also reports new research findings on the virology of the resistance breaking strains, the search for new sources of resistance within *Beta vulgaris* germplasm resources, the national distribution of these strains, and their relationship to the phenomenon of "blinkers" in sugar beet fields with resistant cultivars. This paper also discusses the prospects and research underway to manage this continuing threat to the US sugar beet industry.

Stevens, M., Liu, H.-Y., Lemaire, O. 2006. Virus Diseases. In A. Philip Draycott (ed.) *Sugar Beet*. pp. 256-285 (Book chapter). Blackwell Publishing Ltd, Oxford, United Kingdom.

Sugar beet is susceptible to a number of different viruses that are transmitted by either insects, fungi, nematodes, seed and/or physical contact. All of these viruses have the ability to decrease the potential yield of the root crop as well as affect the extractability of sugar by the processor. Certain viruses such as *Beet necrotic yellow vein virus* (BNYVV), the causal agent of rhizomania, have decimated sugar yields in intense sugar beet producing regions of the world and this virus can dictate where beet can be grown if partially resistant varieties are not grown. With the advance in molecular biology most of the economically important sugar beet viruses have been fully characterised and their DNA or RNA genomes sequenced. This has been particularly useful in understanding how these viruses interact with plants and their vectors, and how they can be better controlled in the future. Such advances have enabled the development of highly specific and sensitive serological and molecular diagnostic methods that have helped to clarify the taxonomic position of certain viruses and their strains, such as the virus yellows complex, as well enabling the identification of new viral species and how sugar beet viruses can interact in the same plant.

Wintermantel, W.M. 2006. Genetic variation among *Beet curly top virus* isolates infecting weed and crop hosts in California. Proc. 20th Annual Tomato Disease Workshop, October 20-21, 2005, Wooster, OH.

Curly top disease is caused by *Beet curly top virus* (BCTV) and related curtovirus species, and is transmitted by the beet leafhopper (*Circulifer tenellus*). The disease occurs in several large, but geographically separate regions of western North America. BCTV re-emerged in 2001 as a serious threat to agriculture in the San Joaquin Valley of California and has continued to exert pressure on agriculture in this region. BCTV infects a broad range of crop hosts including sugar beet, pepper, and tomato, as well as numerous native weeds. Prior molecular characterization of a limited number of curtoviruses from broad areas of the western United States suggested that two distinct curtovirus species, *Beet severe curly top virus* (BSCTV or CFH strain) and *Beet mild curly top virus* (BMCTV or Worland strain) were responsible for most crop disease, but little information existed on curtovirus species distribution among weed hosts or species prevalence in the California sugarbeet crop. The aim of this study was to clarify the genetic variability among curtovirus isolates in California, and to determine if specific weed hosts might be reservoirs for exceptionally severe virus species, such as BSCTV. Data collected over 2 years focused on molecular characterization of large numbers of BCTV isolates from weed and crop hosts of the beet leafhopper in the San Joaquin Valley. Total nucleic acid was isolated from individual plants, and both universal and specific primers were used to amplify viral DNA. PCR amplification coupled with sequence analysis identified the prevalence of both BSCTV and BMCTV as the predominant curtovirus species in California, infecting both weeds and crops. The Logan strain of BCTV, historically associated with California, was not identified among over 200 isolates characterized.

Wintermantel, W.M. 2006. Progress on management and control of criniviruses in tomato. Proc. 20th Annual Tomato Disease Workshop, October 20-21, 2005, Wooster, OH.

Two crinivirus species infect Tomato (*Lycopersicon esculentum*): *Tomato chlorosis virus* (ToCV) and *Tomato infectious chlorosis virus* (TICV). Recent studies demonstrated that transmission efficiency and persistence of ToCV in the vector varies significantly among the 4 vectors capable of transmitting ToCV. *Trialeurodes abutilonea* and *Bemisia tabaci* biotype B are highly efficient vectors of ToCV. *B. tabaci* biotype A and *T. vaporariorum* are less efficient vectors. The complete nucleotide sequence of the bipartite genome of ToCV was sequenced and compared with related crinivirus species. RNA 1 is organized into four open reading frames (ORFs), and encodes proteins involved in replication, and RNA 2 encodes nine ORFs including genes that encode a HSP70 homolog and two proteins involved in encapsidation of viral RNA. Two forms of resistance have been identified that reduce the impact of criniviruses on tomato. Acylsugar production on foliar trichomes reduces vector feeding and can slow the rate of TICV transmission under field conditions. Resistance to TICV infection was recently discovered in a wild species and studies are in progress to determine the efficacy of moving this resistance into cultivated tomato.

Wintermantel, W.M. 2006. Sections on Diseases caused by viruses and virus-like entities, including Introduction, *Beet yellows virus, Beet curly top virus, Cucumber mosaic virus, Beet mosaic virus, and Beet mild yellowing virus*. In: Compendium of Beet Diseases. R.M. Harveson and L.E. Hanson, eds., APS Press, St. Paul, MN. (Book chapter).

Wintermantel, W.M., Anchieta, A.G., and Mosqueda, N.F. 2005. Genetic variation among *Beet curly top virus* isolates infecting weed and crop hosts in California. Proc. American Society of Sugar Beet Technologists, Palm Springs, CA, March 2-5, 2005. pp175-176.

Curly top disease is caused by *Beet curly top virus* (BCTV) and related curtovirus species, and is transmitted by the beet leafhopper (*Circulifer tenellus*). The disease occurs in several large, but geographically separate regions of western North America. BCTV re-emerged in 2001 as a serious threat to agriculture in the San Joaquin Valley of California and has continued to exert pressure on agriculture in this region. BCTV infects a broad range of crop hosts including sugar beet, pepper, and tomato, as well as numerous native weeds. Prior molecular characterization of a limited number of curtoviruses from broad areas of the western United States suggested that two distinct curtovirus species, *Beet severe curly top virus* (BSCTV or CFH strain) and *Beet mild curly top virus* (BMCTV or Worland strain) were responsible for most crop disease, but little information existed on curtovirus species distribution among weed hosts or species prevalence in the California sugarbeet crop. The aim of this study was to clarify the genetic variability among curtovirus isolates in California, and to determine if specific weed hosts might be reservoirs for exceptionally severe virus species, such as BSCTV. Data collected over 2 years focused on molecular characterization of large numbers of BCTV isolates from weed and crop hosts of the

beet leafhopper in the San Joaquin Valley. Total nucleic acid was isolated from individual plants, and both universal and specific primers were used to amplify viral DNA. PCR amplification coupled with sequence analysis identified the prevalence of both BSCTV and BMCTV as the predominant curtovirus species in California, infecting both weeds and crops. The Logan strain of BCTV, historically associated with California, was not identified among over 200 isolates characterized.

Wintermantel, W.M., Kaffka, S.R., and Cortez, A.A. 2005. The impact of plant age and genetics on curly top disease development in modern sugarbeet varieties. Proc. American Society of Sugar Beet Technologists, Palm Springs, CA, March 2-5, 2005. pp193-199.

Performance of current California adapted sugarbeet varieties, which have little resistance to curly top disease, caused by *Beet curly top virus* (BCTV), were compared with some of the most tolerant (Inter-mountain West adapted) and susceptible varieties available for effect of infection on disease severity and plant weight. Field studies conducted in the 1970s demonstrated that sugarbeet plants were more susceptible and losses more severe when seedlings were infected by BCTV, but less severe when plants were larger at the time of infection (Duffus and Skoyen, 1977). To evaluate more precisely the relationship between age at infection and yield loss in modern varieties which were not bred for curly top resistance, individual sugarbeet plants were inoculated with 20 viruliferous beet leafhoppers (*Circulifer tenellus*) each, when plants had either 2, 4 or 6 true leaves, and maintained in a greenhouse for 6 weeks. When plants were inoculated at the 2-leaf stage, all varieties became severely stunted with high disease ratings and similar rates of symptom development, regardless of tolerance or susceptibility of the variety. Plants inoculated at 4 and 6 leaf stages exhibited increasing separation between tolerant and susceptible phenotypes, with highly tolerant varieties performing well with low disease ratings and slower symptom development relative to susceptible varieties. California varieties performed only slightly better than the susceptible control line, Seedex Monohikari. At the conclusion of experiments, soil was carefully removed from beet roots by washing, and total plant biomass was determined. All varieties were severely stunted when inoculated at the two leaf stage, as indicated by individual plant weight. As plants achieved larger size prior to infection, the effect of curly top on total weight was diminished. Results from greenhouse trials matched those from field trials conducted under heavy curly top pressure.

Wintermantel, W.M., Wisler, G.C., Anchieta, A.G., Liu, H.-Y., Karasev, A.V., and Tzanetakis, I.E. 2005. The complete nucleotide sequence and genome organization of *Tomato chlorosis virus*. Archives of Virology 150: 2287-2298.

The crinivirus, *Tomato chlorosis virus* (ToCV), was discovered initially in diseased tomato and has since been identified as a serious problem for tomato production in many parts of the world, particularly in the United States, Europe and Southeast Asia. The complete nucleotide sequence of ToCV was determined and compared with related crinivirus species. RNA 1 is organized into four open reading frames (ORFs), and encodes proteins involved in replication, based on homology to other viral replication factors. RNA 2 is composed of nine ORFs including genes that encode a HSP70 homolog and two proteins involved in encapsidation of viral RNA, referred to as the coat protein and minor coat protein. Sequence homology between ToCV and other criniviruses varies throughout the viral genome. The minor coat protein (CPm) of ToCV, which

forms part of the "rattlesnake tail" of virions and may be involved in determining the unique, broad vector transmissibility of ToCV, is larger than the CPm of *Lettuce infectious yellows virus* (LIYV) by 217 amino acids. Among sequenced criniviruses, considerable variability exists in the size of some viral proteins. Analysis of these differences with respect to biological function may provide insight into the role crinivirus proteins play in virus infection and transmission.

Yu, M.H. 2005. Cyst nematode. pp. 103-109. In (eds. E. Biancardi, L.G. Campbell, G.N. Skaracis, & M. DeBiaggi) Genetics and Breeding of Sugar Beet. Science Publishers, Inc. Enfield, NH, USA. (Book chapter).

Cyst nematode is the most important plant parasitic nematode of sugar beet and is difficult to control. this nematode is widely spread in sugar beet growing areas and occurs virtually wherever the family Chenopodiaceae and Cruciferae plants are grown. It damages sugar beet's primary root system and severely limits sugar beet yield, quality, and sucrose content. Management of cyst nematode in sugarbeet fields is challenging due to the nematode's wide host range and increasing restriction on nematicide utilization. The most promising means of nematode control is through planting resistant cultivars. Development of sugarbeet with resistance to cyst nematode encountered many challenges in the past 60 years. Nonetheless, great progress has been made in scientific discoveries and the resistance breeding. Elite nematode resistant sugarbeet varieties will become available in the foreseeable future.

Yu, M.H. 2005. Root knot nematode. pp. 109-111. In (eds. E. Biancardi, L.G. Campbell, G.N. Skaracis, & M. DeBiaggi) Genetics and Breeding of Sugar Beet. Science Publishers, Inc. Enfield, NH, USA. (Book chapter).

Due to root-knot nematodes' extensive hot range, management through crop rotation and cultivation practices becomes ineffective. Fumigation was the most reliable means of control, but environmental concerns have restricted nematicide usage. Application of soil fumigant Telone (1, 3-dichloropropene) has been prohibited in California since 1990, and methyl bromide (an ozone-depleting fumigant) is being phased out by 2005 under terms of the 1991 Montreal Protocol. Planting nematode-resistant sugar beet, therefore, would be the most economical and environmentally sound tactic. Source of resistance to root-knot nematode has been identified. The resistance is effective against six species of Meloidogyne. Breeding sugarbeet resistance to root-knot nematode is on-going progressively with the use of MAS selection and field trials.

STUDY OF NEW PATHOTYPES OF RHIZOMANIA IN THE UNITED STATES

(Project 261)

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SUMMARY:

Rhizomania is one of the most economically important diseases of sugar beet. It has caused major reductions in root yield and quality. Rhizomania is caused by *Beet necrotic yellow vein virus* (BNYVV) and is vectored by the soil-borne fungus *Polymyxa betae*. The disease can only be controlled effectively by the use of resistant cultivars. During 2003 and 2004 in the Imperial Valley of California, partially resistant sugar beet cultivars with *Rz1* allele seem to be compromised. Distinct BNYVV isolates have been identified. These isolates do not contain RNA-5 as determined by RT-PCR. From the banding patterns of single-strand conformation polymorphism and sequence analyses we concluded that the resistance-breaking BNYVV isolates from Imperial Valley had likely evolved from the original existing A-type. Rhizomania infested sugar beet fields throughout the United States were surveyed in 2004-2005. Our soil survey indicated that the resistance-breaking isolates not only existed in the Imperial Valley and San Joaquin Valley of California but also in Colorado, Idaho, Minnesota, Nebraska, and Oregon. Out of all the soil samples we tested, 92.5% infected Beta 6600 (*rz1rz1*), 77.5% infected Beta 4430R (*Rz1rz1*), 45.0% infected Beta G017R (*Rz2rz2*), and 15.0% infected KWS Angelina (*Rz1rz1+Rz2rz2*). Analyses of the deduced amino acid sequence of coat protein and P-25 protein of resistance-breaking BNYVV isolates revealed the high percentage of identity with non-resistance-breaking BNYVV isolates (99.9% and >98.0% respectively). The P-25 proteins in all isolates consist of 219 amino acid residues and there was a maximum of 10 amino acid differences. The variable amino acids in P-25 proteins were located at the residues of 67and 68. In the United States, the two amino acids found in the non-resistance-breaking isolates were unique (AC), whereas the resistance-breaking isolates were variable (AF, AL, SY, VC, VL, or AC). In order to prove that the 67 and 68 amino acid changes in P-25 protein cause the resistance-breaking, the infectious clones will be needed to draw conclusions.

INTRODUCTION:

Rhizomania disease of sugar beet is caused by *Beet necrotic yellow vein virus* (BNYVV) (Tamada and Baba, 1973; Tamada, 1975) and is vectored by the plasmodiophorid *Polymyxa betae* Keskin (Fujusawa and Sugimoto, 1976). Rhizomania is one of the most economically important diseases of sugar beet. It has caused major reductions in root yield and quality. In the United States, the disease was first identified in California in 1984 (Duffus, et al., 1984), but it now occurs in every major sugar beet production region in the country (Rush, et al., 2006). Most sugar beet production areas are dependent upon resistant sugar beet cultivars to control this devastating disease.

BNYVV is a member of the genus *Benyvirus*. There are three major strain groups of BNYVV that have been reported (Kruse et al., 1994; Koenig et al., 1995; Koenig and Lennefors, 2000). Pathotype A was found in most countries. Pathotype B was observed in Germany and the upper Rhine Valley in France. Pathotype A and pathtype B contained four genomic RNAs.

Pathotype P contains a fifth RNA and seems to be more aggressive, and has so far been found in the region around the French town of Pithiviers and East Anglia in the UK. Other more infective strains of BNYVV have been found in Kazakhstan, China, and Japan. Experimental evidence from Europe, Japan, and the UK has shown that Pathotype P can infect partially resistant beet varieties. The different BNYVV pathtypes can be distinguished by means of restriction fragment length polymorphism (RFLP) and single strand conformation polymorphism (SSCP) analysis of RT-PCR products (Kruse, et al., 1994; Koenig et al., 1995).

During the growing season of 2002-2003 in the Imperial Valley of California, a number of sugar beet fields planted with BNYVV-tolerant cultivars were observed to have severe symptoms of rhizomania. This suggested that the resistance conditioned by the *Rz1* gene had been compromised. Based on host reactions, eight different BNYVV isolates have been isolated from Imperial Valley rhizomania-infested fields (IV-BNYVV) by single local lesion isolation. IV-BNYVV isolates did not contain an RNA-5 as determined by RT-PCR using RNA-5 specific primers. In SSCP analyses of all the IV-BNYVV isolates, the banding patterns were identical to A-type and different from P-type. Sequence alignments of PCR products from BNYVV RNA-1 near the 3' end of IV-BNYVV isolates revealed that IV-BNYVV isolates were similar to A-type and different from B-type. Our results suggest that the resistance-breaking BNYVV isolates from Imperial Valley likely evolved from existing A-type (Liu, et al., 2005). In 2004 and 2005, more BNYVV-resistant breaking fields have been found in the Imperial Valley of California.

In this research, the survey for the resistance-breaking BNYVV isolates in the sugar beet growing regions in the United States were conducted and the coat protein and 25-kDa protein (P-25, encoded by BNYVV RNA-3, involved in symptom expression) of resistance-breaking and non-resistance-breaking BNYVV isolates were sequenced and analyzed.

MATERIALS AND METHODS:

Soil sampling. Two liters of soil sampled from rhizomania infested fields of sugar beet growing areas in the United States were kindly collected by the Agriculturists in the area and sent to the Salinas lab.

Soil test. New 280 ml styrofoam cups with holes punched in the bottom for drainage were placed in sterilized plastic saucers. Cups were filled with infested soil from each soil sample (one part of soil with nine parts of sterilized sand). After cups were filled with appropriate soil samples, they were drenched with fungicides metalaxyl (Apron 25 W) at 0.2 g/liter and PCNB (Terraclor 75 W) at 0.25 g/liter to control damping-off and root rot caused by Pythium spp. and Rhizoctonia spp. Approximately 100 sugar beet seeds were placed on top of each pot and covered with sterilized sand to a depth of approximately 1 cm. Seeds were watered with gentle misting as needed. Following emergence, overhead watering was discontinued and water was added to the saucers directly as needed. Each cup contained different sugar beet varieties, and there were four cups that contained each soil sample. The sugar beet varieties used were rhizomania-resistant varieties: Beta 4430R (*Rz1rz1*), Beta G017R (*Rz2rz2*), and KWS Angelina (*Rz1rz1+Rz2rz2)* and rhizomania-susceptible variety Beta 6600 (*rz1rz1*). Each cup was about 30 cm apart to avoid contamination by splashing between cups. Greenhouses were maintained between 24-30 C. Six weeks post emergence the roots from each cup were harvested and tested for BNYVV by ELISA.

Root extracts preparation. Roots from each Styrofoam cup were washed free of remaining soil. Root tissue (0.2 g from each root mass) was taken from each cup and added to 2 ml of extraction buffer (0.05 M Phosphate-buffered saline, pH 7.2 with 0.5% Tween 20 and 0.4% dry milk powder). Root tissues were homogenized in sample extraction bags with a hand-held roller press (Agdia, Inc.).

Enzyme-linked immunosorbent assay (ELISA): The double antibody sandwich ELISA was used. Purified IgG made to BNYVV (1mg/ml) was used to coat microtiter plates at a 1/1000 dilution, and plates were incubated at 37 C for 1 hour. After washing 3 times with PBS-Tween (3 minutes each), expressed sap (100 µl per well) was added to each of two wells of a microtiter plate and allowed to incubate overnight at 4C. Plates were again washed with PBS-Tween. Alkaline phosphatase-conjugated anti-BNYVV IgG was added to wells (100 µl of 1/1000 dilution). Plates were incubated for 1 hour at 37C, and then washed with PBS-Tween. Alkaline phosphatase substrate (Sigma Chemical, St. Louis, MO) were used at a ratio of 5 mg/8.3 ml of substrate buffer. Absorbance readings (A_{405nm}) were made 1 hr after adding substrate with a Bio-Tek EL312e microplate reader (Winooski, VT). ELISA values of the test samples with an absorbance of A_{405nm} 3 times greater than the healthy mean was considered to be positive.

Reverse transcription-polymerase chain reaction (RT-PCR) and sequence analysis: Viral RNA extracted from infected roots or mechanical inoculated *Chenopodium quinoa* plants using the RNeasy Mini Kit (QIAGEN Inc., Valencia, CA) according to the manufacturer's instructions, was denatured by heating at 95 C for 10 min and annealed with a specific antisense oligonucleotide primer. First strand cDNA and PCR procedures were described previously (Liu, et al. 2003). The PCR products were sliced and gel purified using QIAqueck Gel Extraction Kit (QIAGEN Inc., Valencia, CA) according to the manufacturer's instructions. The eluted DNAs were sequenced by a commercial company (MCLAB, South San Francisco, CA). Sequences were analyzed by the software programs MacVector 7.0 software (Accelrys Inc., San Diego, CA) and AssemblyLIGN (Oxford Molecular Ltd., Oxford, UK).

RESULTS AND DISCUSSION:

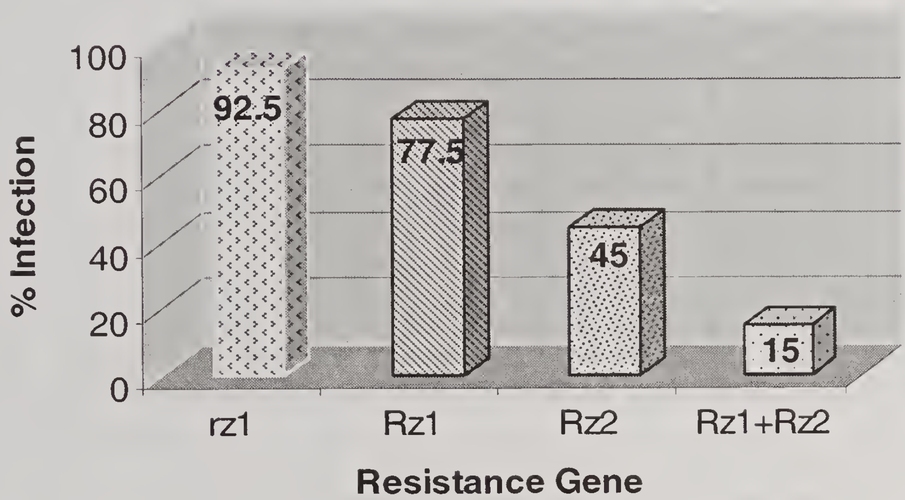
Rhizomania infested sugar beet fields throughout the United States were surveyed for the possibility of infect sugar beet varieties with rhizomania resistance genes, *Rz1, Rz2*, or *Rz1+Rz2.* Standard soil baiting with sugar beet seedlings followed by enzyme-linked immunosorbent assay (ELISA) was conducted. Our soil survey indicated that the resistance-breaking isolates not only existed in the Imperial Valley and San Joaquin Valley of California but also in Colorado, Idaho, Minnesota, Nebraska, and Oregon (Table.1). The results indicated that out of all the soil samples we tested, 92.5% infected Beta 6600 (*rz1rz1*), 77.5% infected Beta 4430R (*Rz1rz1*), 45.0% infected Beta G017R (*Rz2rz2*), and 15.0% infected KWS Angelina (*Rz1rz1+Rz2rz2*) (Fig.1).

Table 1. Soil Test for BNYVV from Rhizomania Infested Fields in the United States, 2004-2005

	Beta 6600 (*rz1*)	Beta 4430R (*Rz1*)	G017R (*Rz2*)	KWS Angelina (*Rz1+Rz2*)
California				
Imperial Valley-1	+	+	+	-
Imperial Valley-2	+	+	-	-
Imperial Valley-3	+	-	-	-
Imperial Valley-4	+	+	+	+
Imperial Valley-5	+	+	+	+
Imperial Valley-6	+	+	+	+
Imperial Valley-7	+	+	+	-
Imperial Valley-8	+	+	+	-
San Joaquin Valley-1	+	+	-	-
San Joaquin Valley-2	+	+	-	-
San Joaquin Valley-3	+	-	-	-
Colorado				
Weld County-1	+	+	+	-
Weld County-2	+	-	-	-
Weld County-3	+	-	-	-
Idaho				
Nampa	+	+	-	-
Elwyhee-1	+	+	+	+
Elwyhee-2	+	+	+	+
Elwyhee-3	+	+	+	+
Burley	+	+	+	-
Murtaugh	+	-	-	-
Cassia Co.	+	+	-	-
Minnesota				
Moorhead-1	+	+	+	-
Moorhead-2	+	+	+	-
Moorhead-3	+	+	+	-
Crookston-1	+	-	-	-
Crookston-2	+	+	-	-
Crookston-3	+	+	-	-
Renville-1	+	+	-	-
Renville-2	+	+	-	-
Renville-3	+	+	-	-
Nebraska				
Scottsbluff-1	+	+	-	-
Scottsbluff-2	+	+	+	-
Scottsbluff-3	-	+	+	-
Scottsbluff-4	-	+	-	-
Scottsbluff-5	+	-	-	-
Oregon				
Nyssa-1	+	+	+	-
Nyssa-2	+	+	+	-
Nyssa-3	+	-	-	-
Washington				
Prosser	+	-	-	-
Wyoming				
Worland	-	+	-	-

+ = ELISA value 3 times greater than healthy check.

Fig. 1. Persent Infection of BNYVV on Sugar Beet with Different Resistant Genes in Soil Testing (2004-2005)



Angelina with two factors for resistance (*Rz1* and *Rz2*) had a lower incidence level then either Beta 4430R or Beta G017R with the single allele *Rz1* or *Rz2* for resistance. There were 3 soil samples infected Beta 4430 R that showed positive on ELISA tests, however, they were not infected Beta 6600. These 3 soil samples are under further investigation.

Under high initial inoculum levels and optimum environmental conditions for rhizomania, disease development may appear to break down partially resistant cultivars (Asher, et al., 2002). The soil dilution experiments with resistant and susceptible cultivars that were conducted with two selected soil samples from California indicated that there was no evidence that the inoculum level affected the reaction of rhizomania-resistant cultivars (data not shown).

The coat protein gene from RNA-2 and P-25 protein (encoded by RNA-3, involved in symptom expression) of BNYVV isolates were sequenced. Analyses of the deduced amino acid sequence of coat protein and P-25 protein of resistance-breaking BNYVV isolates revealed the high percentage of identity with non-resistance-breaking BNYVV isolates (99.9% and >98.0% respectively). The coat protein sequence of resistance-breaking isolates and non-resistance-breaking isolates are almost identical, indicating that the resistance-breaking determinant was not on the coat protein gene.

BNYVV RNA-3 facilitates the multiplication and spread of the virus in root tissue and may have a major role in the production of rhizomania symptoms. Tamada et al., 1999 reported that RNA-3 deletion mutants of BNYVV do not cause rhizomania disease in sugar beets. Single amino acid changes in the P-25 protein of BNYVV RNA-3 will determine resistance responses of *Beta vulgaris* spp. *maritima* (Chiba, et al., 2002). Nucleotide sequences for the RNA-3 encoded P-25 protein of resistance-breaking and non-resistance-breaking BNYVV isolates were

Table 2. The *Beet necrotic yellow vein virus* (BNYVV) RNA-3 encoded P25 amino acid residues 67-70 of BNYVV isolates in the United States.

BNYVV Isotate	RNA-3 P25 amino acid position			
	67	68	69	70
IV-1 *	A	C	H	G
IV-2 *	V	L	H	G
IV-3 *	V	L	H	G
IV-4 *	V	L	H	G
IV-5 *	V	L	H	G
IV-6 *	V	L	H	G
IV-7 *	S	Y	H	G
IV-8 *	S	Y	H	G
IV-9 *	A	L	H	G
IV-10 *	A	L	H	G
IV-11 *	V	L	H	G
IV-12 *	V	L	H	G
IV-13 *	V	L	H	G
IV-14 *	V	L	H	G
IV-15 *	V	L	H	G
IV-16 *	V	C	H	G
IV-17 *	V	C	H	G
IV-18 *	V	L	H	G
IV-19 *	V	L	H	G
IV-20 *	V	L	H	G
IV-21 *	V	L	H	G
IV-22	A	C	H	G
IV-23	A	C	H	G
CV-1 *	V	C	H	G
CV-2	A	C	H	G
S-1	A	C	H	G
S-2	A	C	H	G
CO-1 *	A	F	H	G
CO-2	A	C	H	G
CO-3 *	A	C	H	G
ID-1 *	A	L	H	G
ID-2 *	A	C	H	G
ID-3	A	C	H	G
MN-1 *	A	C	H	G
MN-2 *	A	C	H	G
MN-3 *	V	C	H	G
NE-1 *	A	L	H	G
NE-2 *	A	L	H	G
OR-1	A	C	H	G
OR-2 *	A	L	H	G

IV = Imperial Valley, CV = Central Valley, S = Salinas, California.
CO=Colorado, ID=Idaho, MN=Minnesota, NE=Nebraska, and OR=Oregon.
* = Resistance-breaking BNYVV isolates.

determined and deduced amino acid sequences were compared. The P-25 proteins in all isolates consist of 219 amino acid residues and there was a maximum of 10 amino acid differences. The variable amino acids in P-25 proteins were located at the residues of 67 and 68 (Tables 2 and 3). In the United States, the two amino acids found in the non-resistance-breaking isolates were unique (AC), whereas the resistance-breaking isolates were variable including AF, AL, SY, VC, VL, or AC. Interestingly, the most virulence P-type of BNYVV reported from the Pithiviers area of France the tetrad amino acids (67-70) in P-25 was SYHG (Table 3) which was also found in resistance-breaking isolates in California. However, the resistance-breaking isolate with SYHG found in California did not contain RNA-5 (Liu, et al., 2005). In order to prove that the 67 and 68 amino acid changes cause the resistance-breaking, the infectious clones will be needed to draw conclusions.

The large-scale cultivation of resistant cultivars with the sugar beet resistance genes *Rz1* (Biancardi et al., 2002) and *Rz2* (Scholten et al., 1999) may impose selection pressure and lead to partial or total breakdown of resistance. Consequently, the durability of beet cultivars which are resistant to BNYVV should be reassessed, not only to the original A-pathotype but also to those resistant-breaking isolates. Additional sources of resistance with different genetic determinants should also be sought to increase the stability and durability of the resistance. Rational though needs to be given to their individual and combined deployment to help conserve the efficacy of individual resistance genes.

Table 3. The *Beet necrotic yellow vein virus* (BNYVV) RNA-3 encoded P25 amino acid residues 67-70 selected from GenBank

Accession number	Location/Isolate	RNA-3 P25 amino acid position			
		67	68	69	70
AY696123	Austria-A2	A	F	H	G
AY696126	-A4	A	F	H	G
AY734497	Belgium-B1-(1)	A	Y	H	R
AY734498	-B1-(2)	A	H	H	G
AY696128	-B2	A	Y	H	R
AY696130	-B3	A	Y	H	R
AJ239200	China-NM	A	Y	H	G
AF197549	France-F76	A	L	H	G
AF197545	-F72	A	L	H	G
AY734503 *	-F-pith.85	S	Y	H	G
AY696136	-EP32A	A	Y	H	R
AY696141	-EP39A	A	Y	H	R
AY696133	-EP2	S	Y	H	G
AY734499	-C18-(1)	A	H	H	G
AY696155	Germany-G2	A	Y	H	R
AF197551	Italy-I12	A	L	H	G
D84412	Japan-S	A	Y	R	V
AY696163	-Japon	A	Y	H	G
AF197553	Kazakhstan-Kas2	A	L	H	G
AF197558	Netherlands-N7	A	L	H	G

AY696164	-NL3	A	F	H	R
AY696169	Spain-S3	V	C	H	G
AY696170	-S4	A	C	H	G
AY696171	-S5	V	C	H	G
AY696172	-S7	A	C	H	G
AY696173	-S10	V	F	H	G

* = P-pathotype of BNYVV from the Pithiviers area of France.

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IDENTIFICATION OF NOVEL SOURCES OF RESISTANCE TO BCTV FOR BIOREMEDIATION OR GENETIC ENGINEERING

(Project 221)

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Research Sponsor:
California Beet Growers Association and California Industry Research Committee

INTRODUCTION:

During the summer of 2001, *Beet curly top virus* (BCTV) reemerged as an important, economically damaging pathogen of sugarbeet, tomato and pepper throughout widespread areas of the western United States. These areas included California, the Snake River Valley of Idaho and the southwestern desert of west Texas and New Mexico. The disease was particularly severe in California, where extensive plant damage occurred and sugarbeet yields were reduced by several tons per acre, in large part due to losses from curly top disease (Kaffka et al., 2002). The wide host range of BCTV, abundance of the leafhopper vector, and increasing acreage of uncultivated land in some areas has made curly top management increasingly difficult. The present management strategy focuses on the use of BCTV-resistant varieties when available, and large-scale use of insecticides to control the leafhopper vector. BCTV-resistant sugarbeet varieties have been grown with some success (Bennett, 1971), however, resistant varieties do not yield as well as non-curly top resistant varieties in the absence of curly top. The resistance is a multigenic trait with low heritability that is very difficult to move between varieties. Current varieties grown in California have little resistance to curly top (Wintermantel and Kaffka, 2006).

Application of systemic insecticides at planting has also been used to prevent leafhopper feeding and virus transmission, but this is only partially effective (Kaffka et al., 2002). Since the vector needs only a brief feeding interval to introduce the virus into a healthy plant, insecticides will not block virus transmission, but can reduce overall numbers of leafhoppers. In an effort to control the beet leafhopper, and indirectly BCTV, California growers pay $1.27 million annually for the spraying of 80,000-200,000 acres of uncultivated land with insecticide (Clark, 1995). The insecticide applications are directed at the overwintering breeding hosts (annual and perennial weeds) of the leafhopper to decrease the spring populations of the vector (Cook, 1933). Although it is somewhat difficult to measure the efficacy of the insecticide treatments, this control measure is thought to work well in certain years and locations, and be inadequate in others (Morrison, 1969). Many California beet growers have become heavily dependent on the spray program, as well as the use of systemic insecticides, and as a result have been using high yielding sugarbeet varieties with little or no resistance to BCTV.

Following the epidemic of 2001, the California sugarbeet industry began planting earlier to allow beets to reach substantial size before viruliferous beet leafhoppers moved into the fields carrying BCTV. Studies have shown that beets infected at an early age have more severe yield losses than beets that become infected later in development (Duffus and Skoyen, 1977). BCTV was also present in 2002, but beet leafhopper infestation and virus infection occurred much later and impact on the crop was minimal. Growers again planted early in 2003, but in spite of early planting, BCTV infection occurred while plants were still young. Although 2004 and 2005 were milder, it is only a matter of time until California beet growers again experience strong disease

pressure from curly top again. Curly top is also a chronic problem in the Snake River Valley of Idaho and several other western states where curly top incidence and severity varies from year to year. In the 1920s, prior to the introduction of curly top resistant sugarbeet varieties, severe curly top epidemics resulted in 50-70 percent field abandonment in Idaho, and those fields that were harvested yielded less than 6 tons per acre (Blickenstaff and Traveller, 1979). Even with resistant varieties, the virus causes losses in Idaho and other parts of the west, including Montana, Wyoming, Washington, Oregon, and occasionally Colorado, significantly affecting yields in some years.

The inability to manage curly top through traditional means necessitates the use of novel approaches, including molecular genetics. These methods have shown promise with related viruses in other hosts, and should be effective for curly top in sugarbeet as well. New advances in technology are leading to approaches that may ultimately be useful even without the development of genetically modified plants (GMOs). It is in the best interest of the sugarbeet industry to explore new avenues for virus control and prevention, as this may ultimately reduce reliance on chemical control of the beet leafhopper, and lead to effective management of a virus that has been a chronic problem for over a century.

OBJECTIVES:

1. Develop small synthetic DNA contructs capable of interfering with the BCTV (curly top virus) infection process, based on current knowledge of gene silencing.
2. Insert these constructs into a virus-based vector capable of delivering constructs to infected plants.
3. Test constructs on a model host (tobacco) and on sugarbeet to determine effectiveness of constructs in preventing virus infection.
4. Deliver constructs to sugarbeet through either genetic engineering or using a mechanical delivery system to essentially vaccinate plants against BCTV infection.

Project Accomplishments and Results from the Current Funding Period:

Objective 1 results: Develop small synthetic DNA constructs capable of interfering with the BCTV (curly top virus) infection process, based on current knowledge of "gene silencing."

Results of studies on BCTV strain identification in infected weed and crop hosts in the San Joaquin Valley demonstrated that the only two BCTV strains of significance in California are the CFH and Worland strains, also known as *Beet severe curly top virus* and *Beet mild curly top virus*, respectively. Numerous variants exist that are recombinants between these 2 strains and some variation from the original CFH and Worland isolates is present in field isolates. This variation, however, does not appear to be substantial enough to impact our proposed control method. In fact, the region of the viral genome we are targeting is highly conserved between these two viral strains. The results of our studies clearly demonstrate that CFH and Worland are the two strains that should be targeted for control of BCTV in California (See 2004 BSDF Report). Consequently, we have developed constructs for virus induced gene silencing (VIGS) that should be capable of inducing silencing of both CFH and Worland strains, regardless of which would be introduced to the plant in the field by viruliferous beet leafhoppers.

DNA constructs were designed to target the C1 ("rep") gene of BCTV. This gene is critical for virus replication and host infection, and its "elimination" or inactivation would prevent the virus from infecting the plant. Considerable research has been conducted on both plant and animal systems that have led to an understanding of what types of genetic features trigger gene

silencing. The constructs we have developed to date incorporate features shown through research to be inducers of gene silencing with both RNA and DNA viruses. Contructs were designed using the latest technology, and ordered from Invitrogen, Inc. (Carlsbad, CA), a company specializing in the manufacture of synthetic DNA for research.

Objective 2 results: Insert these constructs into a virus-based vector capable of delivering constructs to sugarbeet plants.

We are using not only the virus based vector method, but also another approach for delivering constructs to sugarbeet. This takes a little more time than focusing on a single method, but allows us to test different delivery methods, since some methods may be more effective than others. The dual approach eliminates some of those variables.

We are introducing some constructs with a modified version of *Tobacco mosaic virus* (TMV), developed by a colleague. In this approach, constructs used to initiate silencing of a gene involved in BCTV replication are incorporated individually into a specific location within the TMV genome. When TMV infects the sugarbeet plant, the target sequence is expressed as RNA and should induce a systemic signal in the plant and eliminate BCTV, preventing development of curly top disease.

In a second approach, we are introducing the constructs to plants using agro-infiltration. In this method, the same constructs are introduced individually to a piece of circular DNA in the bacterium, *Agrobacterium tumefaciens*, known as the Ti Plasmid. *A. tumefaciens* cells are grown in laboratory culture and used to inoculate plants through a process known as agro-infiltration. During this process the constructs are delivered to plant cells and expressed as RNA, which should trigger VIGS.

Three different types of constructs have been developed with each delivery system (6 constructs total) to date.

Objective 3 results: Test constructs on a model host (tobacco) and sugarbeet to determine the effectiveness of each construct in preventing infection and virus accumulation.

Testing of initial constructs is nearly complete using both TMV and agro-infiltration delivery methods. Two approaches were used. In the first, tobacco (control host) plants were inoculated with the BCTV-CFH strain using viruliferous leafhoppers 1 week prior to treatment with silencing constructs. The purpose of this experiment was to determine if treatment would cause the plant to bring virus under control, and would be successful if new leaves emerged on infected plants, but did not express curly top symptoms. The test has been conducted twice, and did not produce recovery. We acknowledge that treating plants with a construct and expecting recovery was a long shot, but if successful it would be a powerful tool for virus control, and would certainly demonstrate the effectiveness of the constructs. We do not intend to pursue efforts at "curing" existing infections further, but rather will focus on preventing infection from developing.

The second approach is our favored method, and one for which we believe we are more likely to prevent BCTV infection. In this case, young sugarbeet and tobacco plants were treated with VIGS constructs using either the agro-infiltration method or TMV vector for delivery of constructs, followed by inoculation with BCTV 2, 5, 7 or 9 days later. Experiments using agro-infiltration and the TMV vector were conducted separately as entirely independent experiments.

Some tests have shown promise using both delivery systems. Two types of constructs have been most successful in both systems. One of these involves what we call a (-) sense or "antisense" construct. This corresponds to the DNA sequence that is complementary to the sequence encoding viral proteins. The second type of construct that is effective is a duplex, either involving two sequences that are complementary to one another and can bind to each other in the plant, or a single construct that can form a "hairpin" shape by folding together. A third type of construct referred to as (+) sense was not effective. Results with these constructs are shown below in Figures 1 and 2.

Results indicate that plants treated with (+) sense constructs were no different than untreated plants inoculated with BCTV (Figure 1 "control") and do not show promise for curly top control, since they did not reduce either disease severity (Figure 1) or virus concentration (Figure 2). In contrast, plants treated with both the (–) sense and hairpin constructs exhibited both decreased disease severity compared with controls (Figure 1) and reduced virus concentration (Figure 2). Not all plants of all varieties responded uniformly, but overall results within treatments were comparable. The hairpin construct, or approach using both constructs together holds the most promise, as some plants treated with the combination of both (+) and (–) sense constructs together resulted in some plants with very low virus concentration relative to virus inoculated plants that were not treated with constructs (Figure 2). Additional work is in progress with (–) sense, hairpin, and both (+) and (–) constructs together.

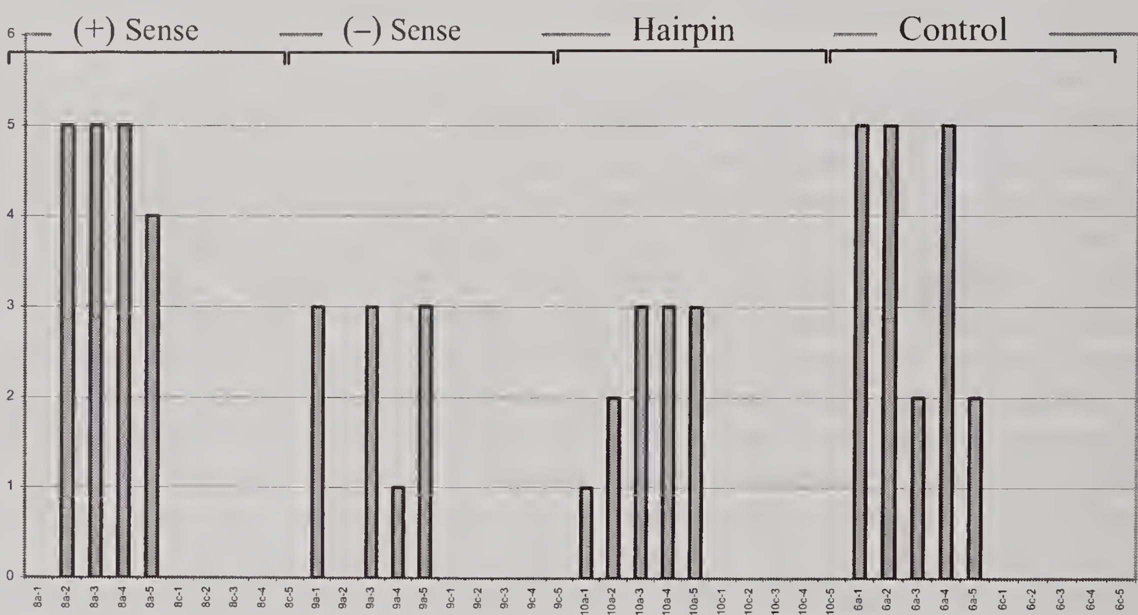

Figure 1. Curly top disease severity for individual tobacco plants treated with 3 silencing constructs delivered by Agro-infiltration. Vertical axis indicates curly top disease severity index score (0=no symptoms, 6=severe symptoms). Horizontal axis lists individual plants by treatment number; 8=(+) sense construct, 9=(–) sense construct, 10=hairpin construct, 6=construct with no silencing insert (neg. control treatment). The first 5 bars (on the left) under each construct heading were treated with the construct and inoculated with BCTV-CFH strain. The second 5 bars (on the right) under each construct heading were treated with the construct but not inoculated with virus and served as negative controls for each treatment. For construct details see text above. Results indicate approximately 40% reduction in disease severity overall with both (–) sense and hairpin constructs.

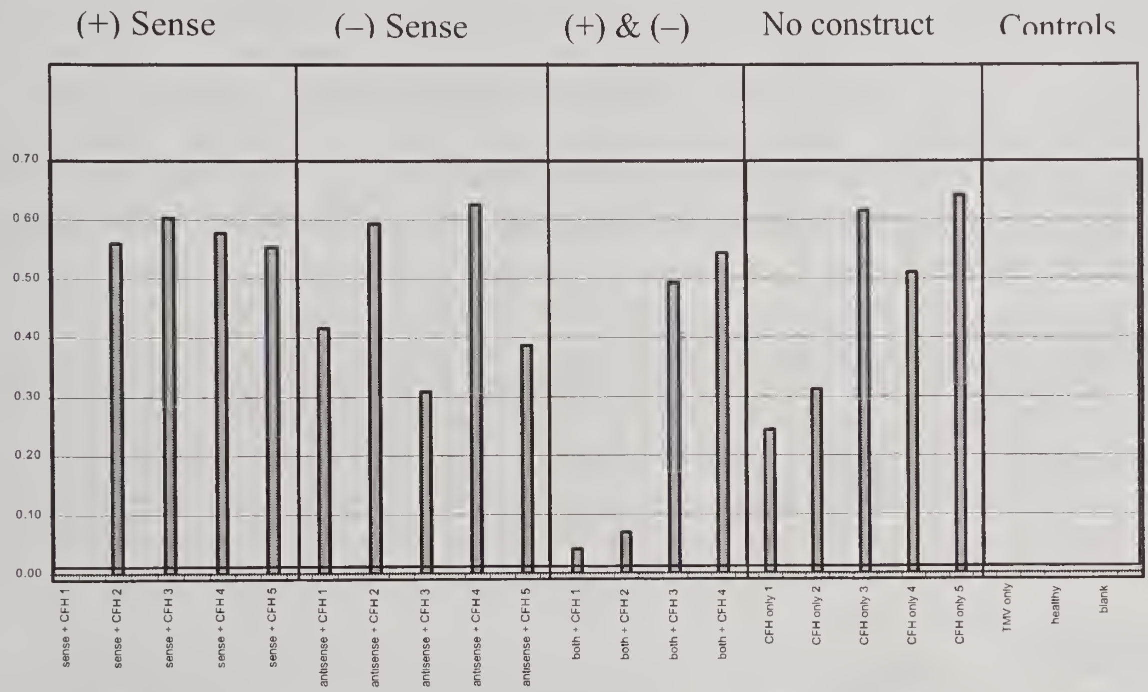

Figure 2. BCTV concentration in tobacco plants treated with (+ sense), (–) sense, and both constructs together using TMV delivery system. Vertical axis lists virus concentration as measured by ELISA using antiserum against BCTV. Horizontal axis indicates virus concentration in each construct. All plants were inoculated with BCTV-CFH strain 7 days after treatment with construct, except for "TMV only," which is the delivery construct alone and healthy control. Results indicate reduction in virus concentration with the (+) & (–) constructs together.

Objective 4: Deliver constructs to sugarbeet through either genetic engineering or using a mechanical delivery system to essentially "vaccinate" plants against curly top.

Development of field delivery systems will begin upon identification of effective constructs for control of BCTV (Objective 3), but will not begin this year. Methods for treatment of plants will be targeted toward young seedlings in the field.

Where We Are Now:

Substantial progress has been made toward objectives within the past year. This includes initial completion of objectives 1 and 2, and progress on objective 3. Initial constructs are not providing complete control, but are clearly reducing virus concentration and disease severity in our test system (tobacco). Tobacco is well studied for effectiveness of gene silencing and is often used as a model when developing new methods. We have tested constructs on sugarbeet as well, but results were inconsistent, possibly because promoters are better adapted to the tobacco system than for sugarbeet. Continuation of research will allow us to improve these constructs through modification and develop additional new constructs that may ultimately lead to complete control. Within the next year we hope to add sugarbeet promoters to adapt the system for better performance on sugarbeet.

Time Line of Anticipated Accomplishments:

This is a three-year project with continuous objectives. The first full year (2005) involved development of initial gene constructs, insertion of these constructs into the TMV and Agrobacterium vectors, and initial stages of testing. Year two will involve a continuation of this process, examining additional constructs, making modifications to improve initial constructs and exploring a third delivery system. By year three we hope to begin examining methods for field application, and conclude construct testing.

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DEVELOPMENT OF SUGARBEET BREEDING LINES AND GERMPLASM

(Projects 211 and 215)

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CR11-88 - CR11-88 (PI640419) is a moderately based, self-fertile (*S^f*), multigerm (*MM*), sugarbeet (*Beta vulgaris* L.) population with moderate resistance to Cercospora leaf spot caused by *Cercospora beticola* Sacc.). CR11-88 segregates for hypocotyl color (*R*), genetic male sterility (a_1a_1), and resistance to rhizomania caused by *Beet necrotic yellow vein virus* (BNYVV) conditioned by *Rz1*. It is moderately susceptible to powdery mildew caused by *Erysiphe polygoni* DC [syn. *E. betae* (Vanha) Weltzien]. In the BSDF curly top nursery, CR11-88 was rated 4.3 and moderately susceptible in comparison to C37 (rated 3.5) and susceptible SP7622-0 (rated 5.2). CR11-88 has moderate to good nonbolting tendency. In an overwintered trial at Brawley, the experimental hybrid CR311-88H50 bolted 0.9% (lsd 0.05=2.8%) as compared to 0.5% for the mean of four leading commercial hybrids.

As a line, CR11-88 produces large, erect canopy and tall seed stalks. It gives high root weight with average sucrose concentration. In tests at Salinas, CA, Fort Collins, CO, and Shakopee, MN, CR11-88 had leaf spot ratings equal to SP7622-0, a moderately resistant check. In the experimental hybrid CR311-88H50 [= (C790-68CMS x C790-15) x CR111-88], the leaf spot ratings were better than 'Monohikari' and 'HM-E17' and produced high gross sugar yield equal to that of the mean of four current commercial hybrids grown in California under both rhizomania and nonrhizomania conditions.

CR11-88 is the second increase of one half-sib family. When the population that became CR11 (PI636343), released in 2005, was recombined in 2001 from selected S_1 progenies, seed from each genetic male sterile plant was harvested separately. In 2002, these half-sib families were evaluated under nonrhizomania and rhizomania conditions for components of yield. The rhizomania test was also inoculated with *C. beticola* and moderate leaf spot occurred. Separately, the half-sibs were evaluated in an overwintered nursery for nonbolting tendency. Progeny line CR111-88 was selected based on sugar yield, sucrose concentration, and resistance to leaf spot and rhizomania. In 2003, stecklings were increased in bulk and crossed to F_1CMS (C790-68CMS x C790-15) to produce line CR311-88 and experimental hybrid CR311-88H50. In 2004 and 2005, the line and hybrid are being evaluated in trials at Salinas and Brawley, CA, Kimberly, ID, Fort Collins, CO, and Shakopee, MN. Based upon the results of the 2004 trials, roots of CR311-88 selected for resistance to rhizomania were increased in bulk to produce CR511-88 that is being released as CR11-88. The released seed of CR11-88 will be a mix of selfed and sibbed matings.

CR11-88 will have about 12.5% of its germplasm from Italian accessions with moderate resistance to Cercospora leaf spot (see description in Official Release of CR11, 2005). CR11-88 should have the germplasm base of a narrowly bred population descended from one half-sib family. CR11-88 may be useful as a source of leaf spot resistance in germplasm adapted to the western USA. It may be useful also to develop potential pollinator parental lines that combine leaf spot and rhizomania resistance with high yield and nonbolting and some resistance to curly

top. One potential use may be to develop hybrids suited to the Mendota factory district where Cercospora leaf spot, curly top, and bolting in recent years have become an increasing concern.

CP-09CT - CP09CT (PI640418) is a moderately based, self-sterile (S^sS^s), multigerm (*MM*), sugarbeet (*Beta vulgaris* L.) line. CP09CT segregates for moderate resistance to sugarbeet cyst nematode (SBCN) caused by *Heterodera schachtii* (Schmidt), powdery mildew (*Pm*) caused by *Erysiphe polygoni* DC [syn. *E. betae* (Vanha) Weltzien], and rhizomania (*Rz1*) caused by *Beet necrotic yellow vein virus*, and for hypocotyl color (about 60% *R_* plants). It is anticipated that CP09CT will have resistance to *Beet curly top virus*, virus yellows (*Beet yellows virus* and *Beet chlorosis virus*), *Erwinia carotovora betavasculorum*, and bolting equal to or better than C78/3 (PI628752).

CP09CT was developed by inter se crosses among eleven plants selected from C78/3, CP06 (PI632287), and CP07 (PI632288). In May 2003, among other breeding lines, C78/3, CP06, and CP07 were planted into a field known to have severe rhizomania incidence near Dos Palos, CA. Rhizomania development was uniform and severe. In addition, in the seedling stage, uniform and severe curly top developed in the trial and surrounding commercial field. The combination of these diseases caused most plants in the commercial crop and nursery to die of root rot or be severely stunted. From C78/3, CP06, and CP07, four, three, and four mother roots were selected that showed only very mild symptoms to curly top and rhizomania. Because CP06 and CP07 have a C78/3 background, roots from these three lines were recombined in the greenhouse at Salinas to produce seed lot P431CT and experimental hybrid P431H5 (= C833-5CMS x selected mother roots). In August 2004, P431CT was planted in a steckling nursery at Salinas under rhizomania and natural powdery mildew infection. In December 2004, plants were selected for resistance to rhizomania and powdery mildew. Line P531CT was produced in 2005 and released as CP09CT.

CP09CT and its experimental hybrid are being evaluated in field and greenhouse trials at Salinas and Brawley, CA and in the BSDF curly top nursery at Kimberly, ID. Under high initial populations of sugarbeet cyst nematode (SBCN) at Brawley, P431CT segregated for plant vigor. About 25% of the plants had high vigor similar to CP07, which suggested moderate to high field resistance to SBCN. In the greenhouse test at Salinas in infested soil, CP09CT had a mean cyst count of 58/plant with a range from 14 [similar to the evaluation of CP07 (mean = 32 with range of 7 to 100)] to 155 (similar to the mean of 169/plant for two susceptible checks and 95 for the mean of CP06). In these greenhouse tests the SBCN resistant 'Hil-2' (Syngenta Seed Co.) with $Hs\text{-}1^{pro\text{-}1}$ averaged 2.3 cysts per plant. Resistance to SBCN is likely from CP07. In observations at Salinas, CP09CT has a high frequency of plants free of powdery mildew and resistant to rhizomania. In the overwintered trials at Brawley, CP09CT had less bolting than C78/3.

CP09CT has a small component of germplasm from *Beta vulgaris* subsp. *maritima*. Resistance to powdery mildew (*Pm*) is from WB97 (PI546394) and/or WB242 (PI546413) in addition to the slow-mildewing characteristics of C78/3. Resistance to rhizomania is likely *Rz1* from C78/3 but could be augmented by minor gene resistance from selections made within C78/3, CP06, and CP07. Resistance to SBCN is most likely from CP07 and could be from either WB242 or C51 (PI593694). Except for the resistance factors, the influence of wild beet in CP09CT appears to be negligible. CP09CT has fully sugarbeet like traits and its experimental hybrid under nondiseased conditions at Brawley for sugar yield, root yield, sucrose concentration, and bolting was better than most of the other experimental hybrids with the same female component. CP09CT should be evaluated as an advanced germplasm source for the

development of parental lines that combine resistance to many diseases and pests of concern in the western USA.

CN927-202 - CN927-202 (PI640420), CN926-11-3-22 (PI640421), and CN921-306 (PI640422) are partially inbred lines of sugarbeet (*Beta vulgaris* L.) that appear to have moderate to high resistance to sugarbeet cyst nematode (SBCN) (*Heterodera schachtii* Schmidt). For these lines, the source of resistance appears to be *B. vulgaris* subsp. *maritima* from composite cross C50 (PI564243) through C51 (PI593694), also called breeding line R22 (PI590791) in the Salinas breeding program. These three partially inbred lines have C51 parentage in common. Because C51 was developed from a composite cross involving about 60 accessions of *B. vulgaris* subsp. *maritima*, the original wild beet source of resistance to SBCN could not be identified. Nor to date is the exact inheritance of this SBCN resistance known, but it appears to be one or a few major genes with dominant gene action; i.e., the experimental hybrids with these or similar lines and sources have nearly the same level of resistance to SBCN as the lines themselves. The allelic relationships among these three lines for their resistance to SBCN also have yet to be determined. Neither is the genic or allelic relationship to the SBCN resistance segregating in CN12 (PI636338) and likely from WB242 (PI546413) and CN72 (PI636339) released in 2005 known. This resistance is not the $Hs\text{-}1^{pro\text{-}1}$ gene transferred to sugarbeet from the hard-seeded species *B. procumbens*.

CN927-202 is homozygous for red hypocotyls (*RR*), multigerm (*MM*), self-fertile (S^f), segregates for genetic male sterility (a_1a_1), and has a high frequency of *Rz1* for resistance to *Beet necrotic yellow vein virus* (BNYVV). CN927-202 was selected from C927-4 (PI628756). CN927-202 theoretically has 12.5% of its germplasm from *B. vulgaris* subsp. *maritima.* Wild beets were initially crossed to breeding line C54 (PI590802) at Salinas in 1984 to produce population R22 (=C50). After multiple cycles of improvement for agronomic type and resistance to rhizomania and virus yellows, improved R22 (C51) was crossed to an early version of C931 (PI636340) to produce population 5921 in 1995. Population 5921 was again backcrossed to C931 type population to produce population 6927. Individual plants of 6927 were selfed in 1997 to produce a set of S_1 progenies from which 7927-4 was selected. After intraline recombination and improvement, 1927-4 was produced and released as C927-4 in 2002. Because in field tests at Salinas and Brawley, CA, there appeared to be high resistance to an unidentified soil-borne problem, but subsequently thought to be *H. schachtii*, C927-4 was selfed to produce S_1 progenies including 2927-4-202. Progeny 2927-4-202 was selected after being tested at Salinas and Brawley under rhizomania and SBCN conditions and observed to have relatively high performance, particularly under SBCN conditions. The S_1 progeny 2927-4-202 was bulk increased in 2004 to produce 4927-202. A second bulk increase was made in 2005 to produce 5927-202, released as CN927-202.

As line 4927-202, CN927-202 was tested at Salinas and Brawley under rhizomania and severe SBCN conditions. It gave high per se and experimental hybrid performance for sugar yield, suggesting it had resistance to both rhizomania and SBCN. In 2004-2005, individual plants of 4927-202 were evaluated in greenhouse tests for reaction under *H. schachtii* infested soil. Compared to susceptible checks and based on cyst counts, 10 out of 10 plants produced relatively low numbers of nematodes. In subsequent retests in the greenhouse, these same plants again showed moderate to high resistance to cyst nematode and matured cysts appeared to be only partially filled. In 2004-2005 tests at Brawley under severe nematode conditions, the experimental hybrid 4927-202H50 [= F_1CMS(C790-68CMS x C790-15) x CN927-202] yielded 11200 lbs sugar per acre (lsd .05=930) and 14.83% sucrose (lsd .05=0.56) with 0% bolting (lsd

.05=1.3) compared to the mean of six advanced experimental and semi-commercial hybrids with *Hs-1* $^{pro-1}$ resistance from *B. procumbens* of 9500 lbs sugar per acre, 13.90% sucrose, and 0.4% bolting. In this same test the mean of the two most widely grown Imperial Valley commercial hybrids was 7400 lbs sugar per acre, 14.40% sucrose, and 0% bolting. The canopy score used to assess general plant health at harvest was 1.1 (lsd .05=0.5) for CN927-202H50, 2.6 for the mean of the six semi-commercial *Hs-1* $^{pro-1}$ hybrids, and 3.5 for the mean of the two commercial hybrids based on a scale of 1 to 5 where 1 = estimate of expected appearance under healthy conditions and 5 = very poor appearance and/or dead. Soil cores were taken from field plots in mid-season on January 25, 2005, and total counts of *H. schachtii* made. For CN927-202H50, the counts were 3440 eggs + larvae/100 grams soil, for the mean of three of the *Hs-1* $^{pro-1}$ hybrids checked, 1970/100 grams soil, and for the two commercial hybrids, 6470/100 grams soil. In an adjacent test of lines per se, CN927-202 had better sugar yield performance than any other entry including the commercial hybrid checks, suggesting highly effective field resistance to SBCN.

CN927-202 may approach parental line usefulness when hybrids are grown under SBCN conditions. At this time, however, CN927-202 is primarily being released as a source of high resistance to SBCN derived from *B. vulgaris* subsp. *maritima.*

CN926-11-3-22 - CN926-11-3-22 is homozygous for green hypocotyls (*rr*), multigerm (*MM*), self-fertile (S^f), and has a high frequency of *Rz1* for resistance to BNYVV. CN926-11-3-22 was developed specifically because of its apparent resistance to *H. schachtii*. It is estimated that C926-11-3-22 has about 2% of its germplasm descending from *B. vulgaris* subsp. *maritima* through C51. C51 was crossed to C37 (PI590715) in 1992 to produce the equivalent of a BC1F1 population. After four additional backcrosses to recurrent sugarbeet population C931 involving selection for plant type, components of yield, and resistance to rhizomania, BC5F1 population 7926 was produced in 1997. After one cycle of recombination, population 8926 was produced. Tests at Brawley under high temperature, rhizomania conditions showed that at a low frequency, plants with unusually high vigor and performance occurred within this population. In an attempt to isolate and understand this response under the Brawley test conditions, individual plants from population 8926 were selfed. One of these S1 progenies called 9926-11 segregated for this resistant response in progeny tests in 2000. Individual plants from 9926-11 were selfed and one S2 progeny 1926-11-3 selected. From one 1926-11-3 plant, the S3 progeny 2926-11-3-22 was produced and tested at Brawley in 2003. Based upon its reaction to what by then was believed to be resistance to SBCN, the S3 was increased in bulk to produce 4926-11-3-22. Line 4926-11-3-22 was tested in the field at Brawley and in the greenhouse at Salinas in 2005. An experimental hybrid 4926-11-3-22H5 (= C833-5CMS x CN926-11-3-22) was also produced and evaluated in field trials at Brawley. Plants from inbred line 4926-11-3-22 were increased at Salinas in 2005 to produce line 5926-11-3-22, released as CN926-11-3-22. Line CN926-11-3-22 and its experimental hybrid are continuing to be evaluated at Salinas and in disease nursery trials.

CN926-11-3-22 may be homozygous for resistance to *H. schachtii.* In preliminary tests in the greenhouse against *H. schachtii*, 10 out of 10 plants showed low rates of nematode reproduction based on cyst counts as compared to susceptible checks. In the same field test at Brawley mentioned above for CN927-202 in which the hybrid of CN927-202 yielded 11200 lbs sugar per acre, the experimental hybrid of CN926-11-3-22 gave 10600 lbs sugar per acre, 15.4% sucrose, and 0% bolting, and had a canopy score of 1.4. Just like CN927-202, in the adjacent test at Brawley of lines per se, the inbred CN926-11-3-22 was not significantly different in yield compared to the hybrid checks. In a companion nondiseased trial at Brawley, the experimental hybrid CN926-11-3-22H5 was nearly equal to the mean of the commercial hybrid checks for

sugar yield and superior for sucrose concentration. Greenhouse tests under SBCN conditions suggested that CN926-11-3-22 was more resistant to *Fusarium oxysporum* f.sp. *betae* than were most other entries.

CN926-11-3-22 approaches commercial parental line traits when the hybrids are grown under both diseased (SBCN and/or rhizomania) and nondiseased conditions. Tests to determine reactions to other diseases and pests are underway. CN926-11-3-22 may be the same or different source of resistance to SBCN as CN927-202, both likely coming from wild sea beet. Hybrids produced with CN926-11-3-22 may be useful in regional, national, and international trials to evaluate the efficacy and usefulness of this source of resistance to reduce damage from cyst nematode.

CN921-306 - CN921-306 is homozygous for green hypocotyls (*rr*), multigerm (*MM*), self-fertile (S^f), and has a high frequency of *Rz1* for resistance to BNYVV. CN921-306 was specifically identified and selected because of its apparent resistance to *H. schachtii*. It is estimated that CN921-306 has about 27% of its germplasm from *B. vulgaris* subsp. *maritima* sources. Unlike CN927-202 and CN926-11-3-22, CN921-306 retains obvious wild beet traits. It is easy bolting or possibly segregates for annualism (*B*). Seed stalks are lax and readily lodge. One of the wild beet components of CN921-306 came through C51. The other sources are C26 (PI610488) and C27 (PI610489). C26 and C27 are improved populations that are approximately half sugarbeet and half *B. vulgaris* subsp. *maritima* from collections made in France, UK, Ireland, and northern Europe. Genetic male-sterile plants from population 8926 (see CN926-11-3-22 above) were crossed to C26 and C27 in 2000 to produce population 0921. Population 0921 was selected for resistance to rhizomania and improved for agronomic traits and components of sugar yield to produce population 2921 in 2002. Population 2921 segregated at a low frequency in tests at Brawley for high vigor under high temperature, SBCN/rhizomania conditions similar to the source populations of CN927-202 and C926-11-3-22. Individual plants from 2921 were selfed and based upon progeny tests in 2004, S1 progeny 3921-306 was increased to produce 5921-306, released as CN921-306. Little is known about CN921-306 except that in the S1 progeny tests, it was superior in yield performance and apparent resistance to SBCN to C927-4. In greenhouse SBCN tests at Salinas in 2004-2005, 8 out of 10 plants showed moderate to high resistance to *H. schachtii*. The relationship of this resistance to that found in CN927-202 and CN926-11-3-22 has not been investigated.

CN921-306 may be useful as a potential source of resistance to cyst nematode that may or may not be different from other released sources.

Reaction of Sugarbeet to *Beet Chlorosis Virus*: Evaluation of Breeding Line and Hybrid Performance under Bchv Infected Conditions, Salinas, CA 1997 - 2003

A disease of sugarbeet exhibiting severe foliage yellowing and necrosis has been occurring with increasing frequency in Colorado and Nebraska during recent years. Symptoms resemble those induced by beet western yellows virus (BWYV), including yellowing of the older and middle leaves, thickening, brittleness and the development of *Alternaria* on the yellowed tissue. The virus inducing this disease has been show to be transmitted by the green peach aphid. Preliminary host range, serological and molecular studies indicate that the new virus is not BWYV. The host range is distinct from common isolates of BWYV found in the USA and from

typical isolates of beet mild yellowing virus (BMYV) which is found in Europe. This new virus can be distinguished from BWYV and MBYV by its ability to infect *Chenopodium captitatum* but not *Capsella bursa-pastoris*. Serological and molecular studies have indicated differential reactions from BWYV and MBYV, but have not yet produced a specific probe to distinguish the virus. The disease appears similar to yellowing isolates found in California and Texas, and thus may have wide distribution. Little information is presently available regarding the ecological and epidemiological factors that allow this virus to increase over such a wide area. (Duffus, J.E., Wisler, G.C., Liu, H.Y., Ruppel, E.G., and Kerr, E.D. 1999. A new aphid-transmitted yellowing virus disease of sugarbeet in Colorado and Nebraska. J. Sugar Beet Research 36(1-2):63).

A yellowing disease of sugarbeet has been frequently observed in Colorado, Nebraska, Texas, and California sugar beet fields since early 1990s. symptoms of this disease are identical to those caused by beet western yellows virus (BWYV) including interveinal yellowing, thickening and brittleness of older leaves and necrotic lesions caused by Alternaria sp. BWYV has a wide host range and is readily distinguished by systemic infection of shephard's purse (Capsella bursa-pastoris) and lack of infection of Chenopodium capitatum. These newly described isolates have a narrow host range and show interveinal reddening on C.capitatum but do not infect shepherd's purse. This disease is readily transmitted in a persistent manner by the green peach aphid (Myzua persicae), but is not mechanically transmissible. The virus has been purified and the isometric virus particles are 22mm in diameter. The coat protein from purified preparations is ca. 23kDa. Serological analysis and biological properties indicate that the virus is distantly related to, but distinct from BWYV. We proposed to name this virus beet Chlorosis virus. (Liu, H.Y., Wisler, G.C., Sears, J.L., and Duffus, J.E. 1999. Beet Chlorosis Virus – A new luteovirus affecting sugarbeet. J. Sugar Beet Research 36(3):69.

Virus yellows is a complex of aphid vectored viruses that may include beet yellows, beet western yellows (BWYV), beet mosaic, and in Europe, beet mild yellows (BMYV) viruses. Recently, a new luteovirus of sugarbeet was recognized in California, Texas, Colorado, and Nebraska that is similar to BWYV and BMYV. It has been named beet Chlorosis virus (BChV). BChV has a different host range that BWYV or BMYV. The host range of BChV includes *Chenopodium capitatum* causing leaves to turn red which lead to the virus affectionately being called "captitatum red." On sugarbeet, foliar symptoms are similar to BWYV but with a tendency for greater interveinal yellowing with distinct green veins. BChV was used in 1997 to inoculate sugarbeet variety trials at Salinas and Davis, California to determine its effects on yield and the occurrence of differential host-plant reactions. the yield reduction caused by BChV was similar but probably more severe than that caused by BWYV. Sugar yield losses ranged from about 5 to 40%. In general, the reactions fit the loss pattern known for BWYV and BMYV. Lines and hybrids from the virus yellows resistance breeding program at Salinas tended to show the most resistance. The most susceptible commercial hybrids tested were those that have been grown in Colorado and Nebraska where BChV has caused significant damage in several recent years. (Lewellen, R.T., Wisler, G.C., Liu, H.-Y., Kaffka, S.R., Sears, J.L., and Duffus, J.E. 1999. Reaction of sugarbeet breeding lines and hybrids to beet Chlorosis virus. J. Sugar Beet Research 36(3): 76.

Table 1. Breeding line performance of sugar beet in trials at Salinas, CA in 1997, 2002, and 2003 under *Beet Chlorosis virus* (BChV) inoculated and noninoculated conditions.

Year,Test	Virus Yellows[a] Score	Sugar Yield[b] Loss(%)	Sugar Yield[c] kg ha^{-1}	Root Yield t ha^{-1}	Sucrose %	Purity[d] %
1997,15: BChV inoculated[e,g]						
Mean	3.6	18.0	9500	71.2	13.3	79.4
Range	2.6-5.4	4.0-37.4	5000-12700	47.9-92.1	9.8-15.0	74.7-82.3
LSD (.05)	0.5		900	6.1	0.5	2.1
CV (%)	13.3		9.7	8.7	3.9	2.7
F value[q]	**		**	**	**	**
1997,18: noninoculated[f,g]						
Mean			11600	84.1	13.7	80.4
Range			6700-15200	52.3-102.4	10.9-14.9	78.6-82.6
LSD (.05)			900	6.3	0.5	2.1
CV (%)			8.0	7.6	3.9	2.7
F value[q]			**	**	**	**
2002,21: BChV inoculated[h,k,r]						
Mean	3.9	11.9[j]	16400	101.9	16.0	83.8
Range	2.7-6.9[l]	-2.8-35.8[l]	9900-19100[l]	67.2-115.2	13.1-17.5	81.7-86.0
LSD (.05)	0.4		1600	7.9	0.9	NS
CV (%)	11.4		10.1	7.9	5.6	2.9
F value	**		**	**	**	NS
2002,25: noninoculated[i,k,r]						
Mean	2.2		18500	111.7	16.6	83.9
Range	1.5-4.8		15400-21900	94.3-132.3	15.2-19.4	80.4-86.8
LSD (.05)	0.5		1600	8.1	0.7	2.3
CV (%)	21.2		8.8	7.4	4.4	2.8
F value	**		**	**	**	**
2003,21: BChV inoculated[m,o,r]						
Mean	3.3	22.5[j]	11000	74.8	14.6	83.9
Range	1.9-5.5[p]	11.7-44.3[p]	5900-13900[p]	46.1-95.0	12.2-16.1	79.7-86.6
LSD (.05)	0.3		1100	6.3	0.7	2.5
CV (%)	10.4		10.1	8.6	4.3	3.0
F value	**		**	**	**	**
2003,25: noninoculated[n,o,r]						
Mean	2.2		14300	94.9	15.1	83.1
Range	1.4-4.6		10600-19700	75.4-122.5	13.2-18.2	79.6-87.8
LSD (.05)	0.4		1300	7.1	0.8	2.5
CV (%)	18.5		9.1	7.6	5.5	3.0
F value	**		**	**	**	**

[a]At approximately 3-week intervals following development of leaf symptoms, plots were scored on a scale of 0 to 9 where 9 = 90-100% of the matured leaf area yellowed. The value shown are means over four rating periods.

[b]Separate companion BChV-inoculated and noninoculated tests were grown and relative %loss values calculated from corresponding variety means.

[c]Sugar yield was calculated from root yield and %sucrose on a fresh weight basis.

Table 1. (cont.)

[d]Purity is the ratio of %sucrose to %total soluble solids in raw juice from brei.

[e]Test 15 in 1997 was an RCB with 48 entries x 8 replications planted 4/10/97 and harvested 10/07/97. BChV inoculated 06/10/97.

[f]Test 18 in 1997 was an RCB with 48 entries x 8 replications planted 4/10/97 and harvested 9/30/97.

[g]Tests 15 and 18 were grown under moderate rhizomania conditions.

[h]Test 21 in 2002 was an RCB with 24 entries x 8 replications planted 2/27/02 and harvested 10/15/02. BChV inoculated 5/09/02.

[i]Test 25 in 2002 was an RCB with 48 entries x 8 replications planted 2/27/02 and harvested 10/10/02.

[j]Only the 24 corresponding entries were used to calculated %loss.

[k]Correlation (r) values of corresponding entries in tests 21 and 25 for sugar yield, %sucrose, and virus yellows scores were .63**, .70**, and .92**, respectively.

[l]Correlation (r) values within test 21 for sugar yield vs. virus yellows score and %sugar yield loss vs. virus yellows score were -.63** and .81**, respectively.

[m]Test 21 in 2003 was an RCB with 24 entries x 8 replications planted 3/05/03 and harvested 10/01/03. BChV inoculated 5/09/03.

[n]Test 25 in 2003 was an RCB with 48 entries x 8 replications planted 3/05/03 and harvested 9/29/03.

[o]Correlation (r) values of corresponding entries in tests 21 and 25 for sugar yield, %sucrose, and virus yellows scores were .84**, .89**, and .94**, respectively.

[p]Correlation (r) values within test 21 for sugar yield vs. virus yellows score and % sugar yield loss vs. virus yellows score were -.68** and .79**, respectively.

[q]NS, *, and ** indicate significance at the nonsignificant, $P \leq 0.05$, and $P \leq 0.01$ levels, respectively.

[r]Tests were grown the second year after soil fumigation following strawberries.

Table 2. Virus yellows scores for *Beet chlorosis virus* (BChV) and relative sugar yield loss (%) for representative sugar beet breeding lines in trials at Salinas, CA in 1997, 2002, and 2003.

Breeding line, Description (reference)	1997[a]		2002[a]		2003[a]	
	Score[b]	%loss[c]	Score	%loss	Score	%loss
Susceptible checks[d]						
SP22-0 ( )	-.-	-.-	6.9	35.8	5.5	44.3
US 75 ( )	5.4	30.1	5.2	27.9	4.1	34.5
Z210	-.-	-.-	-.-	-.-	5.1	35.7
Lines selected for VY resistance[e]						
C37 ( )	3.4	10.7	2.7	6.6	2.1	12.5
C31/6 ( )	3.0	13.7	2.9	7.4	2.1	21.0
C76-89-5 ( )	2.6	9.3	2.9	0.6	2.1	17.4
C69 ( )	3.4	9.2	3.5	6.1	3.0	13.6
C931 ( )	3.4	17.7	3.1	5.2	3.3	12.0
C913-70 ( )	2.9	4.0	-.-	-.-	-.-	-.-
C78/2 ( )	2.9	12.2	3.8	8.6	3.4	29.8
C80/2 ( )	2.8	16.1	3.7	10.1	3.4	23.9
Lines with *B. vulgris* subsp. maritima germplasm[e]						
R22Y3(C51) ( )	3.1	10.9	-.-	-.-	-.-	-.-
C67 ( )	3.0	12.2	3.7	5.6	-.-	-.-
R021(C26 x C27) ( )	-.-	-.-	3.1	1.7	2.6	13.1
Y275	-.-	-.-	-.-	-.-	2.8	16.9
LSD (.05)	0.5		0.4		0.3	

[a]See Table 1 for test descriptions, test means, ranges, LSD(.05)'s, CV's, and significance of F values for sugar yield, root yield, %sucrose, %purity, and VY scores.

[b,c]See Table 1.

[d]Susceptibility based on long term observation and tests.

[e]Lines selected for VY resistance include those intentionally and unintentionally selected beginning in 1955 for resistance to *Beet yellows virus*, *Beet western yellows virus* and/or *Beet chlorosis virus*.

Table 3. Progeny line performance of sugar beet at Salinas, CA in 2002 and 2003 under *Beet chlorosis virus* (BChV) inoculated and noninoculated conditions.

Year,Test	Virus Yellows[a] Score	Sugar Yield[b] Loss (%)	Sugar Yield[c] kg ha^{-1}	Root Yield t ha^{-1}	Sucrose %	Purity[d] %
2002,24: BChV inoculated[e,k,r]						
Mean	3.7	17.6[g]	15000	93.5	16.1	83.4
Range	2.1-6.6[l]	2.8-34.0[l]	10500-20000[l]	62.6-117.3	14.4-17.1	81.6-85.1
LSD (.05)	0.3		1550	7.1	0.9	NS
CV (%)	9.1		10.2	7.6	5.8	2.7
F value[q]	**		**	**	**	NS
2002,28: noninoculated[f,k,r]						
Mean	2.2		18100	104.9	17.3	84.0
Range	0.8-4.9		14500-21500	80.1-125.4	16.0-18.6	81.8-86.7
LSD (.05)	0.4		1650	7.0	0.9	2.8
CV (%)	20.0		9.1	6.7	5.3	3.3
F value[q]	**		**	**	**	*
2003,24: BChV inoculated[m,o,r]						
Mean	3.6	17.1[g]	9750	66.5	14.6	82.7
Range	2.2-5.7[p]	6.2-34.7[p]	6050-12700[p]	47.5-79.4	12.7-15.8	79.2-85.7
LSD (.05)	0.4		1150	6.8	0.6	2.1
CV (%)	10.4		11.7	10.3	4.2	2.5
F value	**		**	**	**	**
2003,28: noninoculated[n,o,r]						
Mean	2.3		11750	77.4	15.2	83.2
Range	1.4-4.1		9250-14300	65.1-90.2	13.0-16.4	80.7-85.2
LSD (.05)	0.4		1500	9.2	0.6	1.9
CV (%)	15.8		12.8	11.9	4.1	2.3
F value	**		**	**	**	**

[a,b,c,d,q,r]See Table 1.

[e]Test 24 in 2002 was an RCB with 12 entries x 8 replications planted 2/27/02 and harvested 10/16/02. BChV inoculated 5/09/02.

[f]Test 28 in 2002 was an RCB with 12 entries x 8 replications planted 2/27/02 and harvested 10/18/02.

[g]The 12 corresponding entries were used to calculate % loss.

[k]Correlation (r) values of corresponding entries in tests 24 and 28 for sugar yield, % sucrose, and virus yellows scores were .90**, .89**, and .94**, respectively.

[l]Correlation (r) values within test 24 for sugar yield vs. virus yellows score and % sugar yield loss vs. virus yellows score were -.67* and .92**, respectively.

[m]Test 24 in 2003 was an RCB with 12 entries x 8 replications planted 3/05/03 and harvested 9/30/03. BChV inoculated 5/09/03.

[n]Test 28 in 2003 was an RCB with 12 entries x 8 replications planted 3/05/03 and harvested 9/22/03.

[o]Correlation (r) values of corresponding entries in tests 24 and 28 for sugar yield, %sucrose, and virus yellows scores were .83**, .93**, and .85**, respectively.

[p]Correlation(r) values within test 24 for sugar yield vs. vy score and % sugar yield loss vs. vy score were -.57NS and .83**, respectively.

Table 4. Virus yellows scores for *Beet chlorosis virus* (BChV) and relative sugar yield loss (%) for representative sugar beet progeny lines in trials at Salinas, CA in 2002 and 2003.

Table 4. Virus yellows scores for *Beet chlorosis virus* (BChV) and relative sugar yield loss (%) for representative sugar beet progeny lines in trials at Salinas, CA in 2002 and 2003.

Progeny line, Description	(reference)	2002[a] Score[b]	2002[a] %loss[c]	2003[a] Score	2003[a] %loss
Susceptible checks[d]					
SP22-0	( )	6.6	33.3	5.7	34.7
Progeny lines selected for VY resistance[e]					
C76-89-5-4		2.1	2.8	2.2	10.5
C927-4	( )	2.5	6.6	-.-	-.-
C930-19	( )	2.3	16.2	2.3	10.6
2936-10		-.-	-.-	2.3	6.2
C929-62	( ) 3.3	18.9	-.-	-.-	
C81-22	( )	-.-	-.-	2.9	10.6
Progeny lines selected for other traits[f]					
CZ25-9	( )	6.5	34.0	-.-	-.-
C980-35	( )	5.5	27.5	5.0	31.0
LSD (.05)	0.3	0.4			

[a]See Table 3 for test descriptions, test means, ranges, LSD(.05)'s, CV's, and significance of F values for sugar yield, root yield, %sucrose, %purity, and VY scores.

[b,c]See Table 1.

[d]See Table 2.

[e]Lines selected for VY resistance include those intentionally and unintentionally selected beginning in 1955 for resistance to *Beet yellows virus, Beet western yellows virus* and/or *Beet chlorosis virus*. These progeny lines represented one or more cycles of testing S_1 or FS progenies in inoculated, replicated, progeny tests.

[f]Lines with a similar breeding history as in footnote "e" but selected for other performance traits or disease resistance.

Table 5. Commercial and experimental hybrids in trials at Salinas, CA in 1997, 2002, and 2003 under *Beet chlorosis virus* (BChV) inoculated and noninoculated conditions.

Year,Test	Virus Yellows[a] Score	Sugar Yield[b] Loss(%)	Sugar Yield[c] kg ha^{-1}	Root Yield t ha^{-1}	Sucrose %	Purity[d] %
1997,16: BChV inoculated[e,g]						
Mean	4.2	18.5	8500	68.8	12.2	80.4
Range	3.0-5.4	2.1-36.7	4400-12800	44.5-94.4	9.5-14.8	76.3-84.7
LSD (.05)	0.4		950	6.0	0.8	3.1
CV (%)	10.5		11.3	8.8	6.4	3.9
F value[q]	**		**	**	**	**
1997,19: noninoculated[f,g]						
Mean			10500	77.2	13.4	83.2
Range			5800-13800	52.3-95.5	10.3-15.8	80.7-85.7
LSD (.05)			1000	6.1	0.6	2.4
CV (%)			9.9	8.1	4.6	3.0
F value[q]			**	**	**	**
2002,22: BChV inoculated[h,k,r]						
Mean	4.6	17.9[j]	17100	103.0	16.6	85.0
Range	2.9-6.6[l]	2.7-32.9[l]	13200-20300[l]	83.8-122.9	15.2-19.1	82.7-87.9
LSD (.05)	0.4		1400	6.8	0.7	1.8
CV (%)	8.5		8.3	6.7	4.0	2.1
F value	**		**	**	**	**
2002,26: noninoculated[i,k,r]						
Mean	2.0		20900	120.0	17.5	85.5
Range	1.2-3.6		19200-23800	105.2-180.1	16.3-19.7	82.9-85.0
LSD (.05)	0.6		1450	6.4	0.7	1.8
CV (%)	28.1		7.1	5.5	4.3	2.1
F value	**		**	**	**	**
2003,22: BChV inoculated[m,o,r]						
Mean	3.9	22.5[j]	11100	75.9	14.6	83.9
Range	2.5-5.3[p]	11.6-40.5[p]	7300-13700[p]	57.0-89.5	12.7-16.6	81.3-87.0
LSD (.05)	0.3		900	5.5	0.6	2.2
CV (%)	8.9		8.4	7.4	4.2	2.7
F value	**		**	**	**	**
2003,26: noninoculated[n,o,r]						
Mean	2.4		14300	92.2	15.1	83.8
Range	1.5-4.0		12100-17100	83.3-110.4	12.6-17.8	80.0-86.8
LSD (.05)	0.4		1400	6.5	1.0	3.2
CV (%)	15.3		9.9	6.9	6.5	3.9
F value	**		**	**	**	**

[a,b,c,d,q]See Table 1.

[e]Test 16 in 1997 was an RCB with 24 entries x 8 replications planted 4/10/97 and harvested 10/2/97. BChV inoculated 6/10/97.

[f]Test 19 in 1997 was an RCB with 24 entries x 8 replications planted 4/10/97 and harvested 9/29/97.

[g]Tests 16 and 19 were grown under moderate rhizomania conditions.

[h]Test 22 in 2002 was an RCB with 24 entries x 8 replications planted 2/27/02 and harvested 10/15/02. BChV inoculated 05/09/02.

Table 5. (cont.)

[i]Test 26 in 2002 was an RCB with 24 entries x 8 replications planted 2/27/02 and harvested 10/09/02.

[k]Correlation (r) values of corresponding entries in tests 22 and 26 for sugar yield, %sucrose, and virus yellows scores were .16NS, .92**, and .81**, respectively.

[l]Correlation (r) values within test 22 for sugar yield vs. virus yellows score and %sugar yield loss vs. virus yellows score were -.76** and .86**, respectively.

[m]Test 22 in 2003 was an RCB with 24 entries x 8 replications planted 3/05/03 and harvested 10/01/03. BChV inoculated 5/09/03.

[n]Test 26 in 2003 was an RCB with 24 entries x 8 replications planted 3/05/03 and harvested 9/25/03.

[o]Correlation (r) values of corresponding entries in tests 22 and 26 for sugar yield, %sugar, and virus yellows scores were .83**, .94**, and .89**, respectively.

[p]Correlation (r) values within test 22 for sugar yield vs. virus yellows score and %sugar yield loss vs. virus yellows score were -.66** and .75**, respectively.

Table 6. Virus yellows scores for *Beet chlorosis virus* (BChV) and relative sugar yield loss (%) for representative sugar beet commercial and experimental hybrids in trials at Salinas, CA in 1997, 2002, and 2003.

Hybrid, Description (reference)			1997[a]		2002[a]		2003[a]	
			Score[b]	%loss[c]	Score	%loss	Score	%loss
Checks[d]								
US H11	4.0	15.2	3.9	13.2	3.1	17.0		
KW6770			4.4	35.3	-.-	-.-	-.-	-.-
Beta6600			-.-	-.-	5.9	21.1	4.5	32.5
California commercial hybrids[e]								
Beta4776R	5.4	20.6	5.5	14.2	5.0	18.0		
Beta4454			3.7	18.9	-.-	-.-	-.-	-.-
Phoenix			-.-	-.-	5.0	27.1	4.3	25.7
Rival			5.0	27.1	-.-	-.-	-.-	-.-
Beta4430R			-.-	-.-	6.6	35.5	5.3	27.1
Colorado commercial hybrids[e]								
Monohikari	4.1	33.5	5.2	27.4	3.7	27.7		
HM55			4.9	36.1	-.-	-.-	-.-	-.-
ACH205			4.8	36.7	5.9	23.4	5.2	36.0
Beta6045			-.-	-.-	5.6	26.2	4.6	22.9
HM9155			-.-	-.-	5.2	19.1	3.8	23.1
HM1639			-.-	-.-	6.2	32.9	5.0	40.5
Ranger			-.-	-.-	5.3	18.5	4.2	22.9
Beta4546			-.-	-.-	3.3	8.5	3.2	20.2
Experimental USDA hybrids[f]								
VYRmmCMS x C80/2[g]		3.6	4.4	2.7	2.7	2.8	11.3	
mmCMS x C76-89-5[g]			3.4	2.1	2.9	11.3	-.-	-.-
mmCMS x C913-70[g]			3.0	7.6	-.-	-.-	-.-	-.-
mmCMS x C930-19[h]			-.-	-.-	-.-	-.-	2.5	11.6
mmCMS x C930-35[h]			-.-	-.-	-.-	-.-	3.8	19.3
mmCMS x Z210[g]			-.-	-.-	-.-	-.-	4.5	27.7
LSD (.05)	0.4		0.4		0.3			

[a]See Table 5 for test descriptions, test means, ranges, LSD(.05)'s, VS's, and significance of F values for sugar yield, root yield, %sucrose, %purity, and virus yellows scores.
[b,c]See Table 1.
[d]US H11 is a hybrid of susceptible female parent with a pollinator similar to C37 (Table 2).
[e]Representative commercial hybrids grown at the time in California and the Eastern Slope region.
[f]Hybrids produced at Salinas that have either male or female or both components with parental lines selected for resistance to virus yellows. Female component listed mmCMS is C790-15CMS ( ) that was developed in the presence of natural virus yellows infection; VYRmmCMS is C831-4CMS that was selected and developed for resistance to virus yellows at Salinas.
[g]See Table 2.
[h]See Table 4.

INDEX OF VARIETY TRIALS - SALINAS, CALIFORNIA 2005
U.S. AGRICULTURAL RESEARCH STATION

Tests were located in three field plot areas at Salinas and two at Brawley, CA. Disease nurseries were also used in Idaho, Colorado, and Minnesota. Tests at Brawley (Imperial Valley) were planted in September 2004, and harvested from May through June, 2005. Tests at Salinas were planted from March through August, 2005, and harvested from September through December. Tests at Spence Field (Salinas) were under both rhizomania and nonrhizomania (following methyl bromide fumigation) conditions. Herbicides were not used in Block 4 trials that followed strawberries and methyl bromide fumigation. Nortron, Pyramin, Betamix, Progress, and Poast were used in the other trials. Bayleton at 2lbs material/acre was used for powdery mildew control. Lorsban-4E was applied for aphid and other insect control. The specific planting and harvest dates as well as plot size and design are shown on each test summary.

Tests are listed in the main Table of Contents for Salinas by types of material and evaluation. As an aid to find test summaries, they are listed below by ascending test (planting date) number and cross- referenced to the page number. Tests shown as n/a are not available or not included in this report.

TEST 505. PERFORMANCE OF LINES & POPULATIONS, SALINAS, CA, 2005

48 entries x 8 reps., RCB
1-row plots, 22 ft. long

Planted: April 19, 2005
Harvested: October 4, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	PM Score
Hybrid checks								
Phoenix	9/12/03	14061	40.89	17.20	20.16	85.3	149	4.6
Beta 4430R	8/21/03	16583	46.73	17.73	20.76	85.4	146	2.9
Y491H50	C790-15CMS x RZM Y391	13904	39.72	17.51	21.20	82.6	105	3.4
MM, O.P. lines								
03-SP22-0	Inc. 01-SP22-0	11908	36.88	16.08	19.71	81.6	142	2.8
03-US75	Inc. 00-US75	11121	36.23	15.35	19.24	79.8	138	6.9
04-C37	Inc. 03-C37	12086	36.39	16.61	20.59	80.7	140	6.9
R378 Sp	RZM R178	12939	38.45	16.79	20.63	81.4	116	3.0
R376-89-4	Inc. R176-89-4	10344	30.53	16.92	20.85	81.2	136	4.0
R481-22	RZM R181-22, C81-22	13150	37.51	17.54	21.17	82.8	125	3.3
R476-89	RZM-ER-% R276-89	12511	36.27	17.24	20.91	82.4	140	3.3
Z210	Inc. Z010(C), (Polish %S gp)	13252	33.64	19.70	23.79	82.9	128	4.5
R421	RZM-ER-% R221	14251	42.46	16.79	20.50	81.9	147	3.4
Y475	RZM-ER-% Y275	13400	39.42	17.00	20.77	81.8	141	2.8
Y491	RZM Y391	12985	37.15	17.46	21.10	82.8	93	3.3
Y369	RZM-ER-% Y169	15205	42.48	17.89	21.51	83.2	134	1.8
R380	RZM-ER-% R180	14501	41.91	17.30	21.06	82.1	140	2.6
N472(Sp)	N372,N272-#(C)aa x A, CN72	14221	42.58	16.73	20.51	81.5	135	2.5
N412(Sp)	N312,N212-#(C)aa x A, CN12	14873	44.85	16.58	20.29	81.7	130	1.4
P427	PMR-RZM P327, CP03	13092	39.18	16.71	20.15	83.0	140	2.4
P428	PMR-RZM P328, CP04	15499	46.51	16.66	20.20	82.5	141	1.5
P429	PMR-RZM P329, CP05	13595	40.31	16.85	20.13	83.8	132	1.3
P430	PMR-RZM P330, CP06	15104	43.45	17.39	20.77	83.7	145	1.9
P407/8	PMR-RZM-% P207/8	14300	42.48	16.81	20.59	81.7	141	1.4
P418-6	PMR-RZM P318-6 (Iso)	12675	38.45	16.50	20.26	81.5	146	2.0

TEST 505. PERFORMANCE OF LINES & POPULATIONS, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	PM Score
MM, O.P. lines (cont.)								
P431CT	RZM,CTR,R278,P230,P207/8	14693	42.68	17.23	21.15	81.4	144	1.6
K402	RKNR M6-2	13233	40.08	16.51	19.96	82.7	130	2.4
K403	RKNR M1-3,-3a	14450	43.71	16.52	19.48	84.9	148	5.1
K404	RKNR M1-4	14394	42.33	17.01	20.65	82.4	147	4.5
Y477	RZM-ER-% Y277	13770	40.41	17.06	20.49	83.3	143	3.8
Y492	RZM-ER-% Y292	14526	41.12	17.67	21.41	82.6	140	4.0
Y390	Inc. Y190-#(C), C2, Syn1	14199	39.82	17.83	21.51	82.9	137	4.5
Y393	Inc. FS-#s, C1, Syn 1	15267	44.01	17.34	20.75	83.6	147	2.5
MM,S^f,Aa populations								
04-FC1028	RZM-% FC20021028, (FC709/2 x 9933)	12522	35.63	17.58	21.40	82.1	127	3.0
04-FC1037	RZM-% FC20021037,(FC·LSRxEL·LSR) x CR11	13967	40.21	17.35	21.05	82.4	139	3.9
04-FC1038	RZM-% FC20021038,(FC·LSRxEL·LSR) x CR10	13446	39.25	17.13	20.91	81.9	133	3.9
4921	RZM-ER-% 2921	14251	41.87	17.02	20.64	82.5	139	4.0
3942	RZM 2942aa x A	13105	36.91	17.74	21.31	83.3	133	2.6
4943	RZM 3943aa x A	14875	41.08	18.11	21.71	83.5	130	2.4
Z425	RZM Z325aa x A, CZ25/2	15483	43.39	17.83	21.50	82.9	135	3.8
CR411	RZM CR311aa x A, CR11	13643	40.89	16.66	20.05	83.2	118	4.0
4931	RZM 3931aa x A, C931	14166	40.15	17.65	21.51	82.0	120	3.1
4941	RZM 3941aa x A, C941	15176	43.56	17.41	20.91	83.3	123	3.0
N412(Iso)	PMR-RZM N312 (A,aa)	16332	48.57	16.83	20.07	83.8	148	2.5
N472(Iso)	RZM-NR N372 (A,aa)	14561	44.64	16.36	20.51	79.9	131	1.6
R425	RZM-% R725,R325, (C79-3, WB42)	11037	33.44	16.49	20.26	81.4	133	5.8

TEST 505. PERFORMANCE OF LINES & POPULATIONS, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	PM Score
mm, S^f, Aa populations								
4843m	RZM,T-O 3843-#(C)mmaa x A	11374	33.24	17.10	21.17	80.8	123	4.4
4891m	RZM,T-O 3891-#(C)mmaa x A	13444	38.25	17.58	21.39	82.2	129	4.3
4846m	T-O, RZM 3845,3846-#(C)mmaa x A	13130	38.19	17.19	20.98	81.9	134	4.5
Mean		13762.6	40.16	17.14	20.78	82.5	134.5	3.3
LSD (.05)		1210.2	3.27	0.54	0.61	2.3	14.3	1.1
C.V. (%)		8.9	8.25	3.19	2.97	2.8	10.8	33.0
F value		9.3**	10.00**	11.35**	10.78**	2.1**	4.8**	11.6**

TEST 605. PERFORMANCE OF PROGENY LINES SELECTED FOR VIRUS YELLOWS RESISTANCE, NOT INOCULATED, SALINAS, CA, 2005

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: April 19, 2005
Harvested: October 3, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/100' No.	PM Score
Checks								
03-SP22-0	Inc. 01-SP22-0	11671	36.83	15.80	18.90	83.5	148	2.6
R481-22	RZM R181-22, C81-22	13764	38.65	17.83	21.33	83.6	136	3.3
4930-229	Inc. 2930-35-229 (A,aa)	11313	31.90	17.75	22.04	80.6	127	2.9
Z210	Inc. Z010(C), (Polish %S gp)	13641	33.95	20.11	24.30	82.9	141	3.4
Parental source checks								
3942	RZM 2942aa x A	12774	36.53	17.50	21.74	80.5	135	3.1
Y390	Inc. Y190-#(C), C2, Syn 2	14595	41.28	17.67	20.95	84.4	139	4.8
CR411	RZM CR311aa x A, CR11	13812	41.28	16.74	20.41	82.0	117	3.9
Z425	RZM Z325aa x A, CZ25/2	14731	41.29	17.84	21.45	83.2	132	3.3
4931	RZM 3931aa x A, C931	14398	41.18	17.50	21.71	80.6	128	2.4
4941	RZM 3941aa x A, C941	14410	41.82	17.27	20.85	82.9	127	2.6
Inc. S_1 progeny								
4951-210	Inc. 2951-210 (A,aa)	11199	32.14	17.40	21.16	82.3	118	2.8
4952-202	Inc. 2952-202 (A,aa)	14664	41.07	17.86	21.57	82.8	133	4.4
4952-205	Inc. 2952-205 (A,aa)	12430	33.82	18.36	22.15	82.9	139	2.4
4952-212	Inc. 2952-212 (A,aa)	11646	33.31	17.49	21.34	82.0	134	3.9
4952-222	Inc. 2952-222 (A,aa)	11213	29.77	18.85	23.38	80.7	123	1.6
4953-209	Inc. 2953-209 (A,aa)	10343	29.45	17.55	21.47	81.7	119	1.1
4953-215	Inc. 2953-215 (A,aa)	11366	33.91	16.77	20.40	82.2	119	2.3
4953-217	Inc. 2953-217 (A,aa)	13157	37.73	17.44	21.45	81.3	134	2.1
4954-204	Inc. 2954-204 (A,aa)	11159	32.56	17.13	20.44	83.8	132	4.0
4954-207	Inc. 2954-207 (A,aa)	13826	40.99	16.86	20.23	83.4	138	4.5

TEST 605. PERFORMANCE OF PROGENY LINES SELECTED FOR VIRUS YELLOWS RESISTANCE, NOT INOCULATED, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	PM Score
Inc. S_1 progeny (cont.)								
4954-210	Inc. 2954-210 (A,aa)	12063	32.57	18.54	22.64	81.9	140	2.5
4954-225	Inc. 2954-225 (A,aa)	12598	37.47	16.81	20.88	80.5	131	1.3
4942-202	Inc. 2942-202 (A,aa)	11928	34.41	17.34	21.34	81.3	136	1.3
4942-211	Inc. 2942-211 (A,aa)	10900	30.62	17.80	21.67	82.2	128	1.0
Mean		12650.1	36.02	17.59	21.41	82.2	131.4	2.8
LSD (.05)		1117.8	3.05	0.58	0.63	2.3	15.3	0.8
C.V. (%)		9.0	8.61	3.23	2.99	2.9	11.8	30.4
F value		12.1**	14.37**	17.15**	22.49**	1.9*	2.1*	13.2**

TEST 1205. EVALUATION OF MULTIGERM PROGENY LINES, SALINAS, CA, 2005

48 entries x 4 reps., sequential
1-row plots, 11 ft. long

Planted: April 20, 2005
Harvested: October 10, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/100' No.	PM Score
Checks								
Angelina	2/25/04	16660	46.76	17.80	21.75	81.8	125	2.8
Roberta	2/25/04	16679	47.36	17.60	20.88	84.3	109	1.5
Beta 4430R	8/21/03	17365	48.17	18.00	20.88	86.2	145	1.5
Phoenix	9/12/03	16390	45.75	17.95	20.77	86.4	148	2.0
04-C37	Inc. 03-C37	11818	34.06	17.35	21.38	81.3	145	6.5
R424	RZM-% R724, R324, (C79-2)	12474	36.88	16.93	21.17	80.0	130	2.5
R425	RZM-% R725, R325, (C79-3)	14192	40.91	17.35	21.60	80.4	141	6.3
R424/5	RZM-% R824, R324/5	13027	38.09	17.10	20.90	81.8	136	3.0
R437	RZM-% R637, R337, (C79-9)	13760	38.90	17.70	22.05	80.3	139	3.3
R336	RZM-ER-% R136, (C79-8)	12992	38.70	16.75	21.13	79.3	132	2.0
P418-6	PMR-RZM P318-6(Iso), (CP08)	12907	38.29	16.85	21.48	78.5	120	1.0
P407/8	PMR-RZM-% P207/8, (CP07)	15884	45.55	17.42	21.38	81.6	130	0.5
P428	PMR-RZM P328, (CP04)	15690	45.81	17.13	20.63	83.0	139	0.8
P430	PMR-RZM P330, (CP06)	16029	45.89	17.45	21.25	82.1	136	0.8
N412(Sp)	N312, N212-#(C)aa x A, (CN12)	16368	47.97	17.05	21.45	79.5	118	0.8
N472(Sp)	N372, N272-#(C)aa x A, (CN72)	14265	42.17	16.88	21.15	79.8	109	1.5
Multigerm, O.P. progeny lines								
R480-6 (Sp)	RZM R280-6	16438	46.92	17.52	21.17	82.8	123	2.0
R481-22	RZM R181-22, (C81-22)	15424	42.73	18.05	21.70	83.2	150	1.5
R476-89	RZM-ER-% R276-89	13489	39.50	17.08	21.13	80.8	134	1.0
R480-6 (Iso)	RZM R280-6	16275	47.12	17.27	20.82	83.0	134	2.5
Mulitgerm, S^f, Aa progeny lines								
4941-20 (Sp)	2941-20aa x A	12978	38.74	16.75	21.00	79.8	116	1.8
4941-20 (Iso)	RZM 2941-20 (A,aa)	13013	37.29	17.45	21.55	81.0	139	1.8
4933-14 (Iso)	RZM 2933-14 (A,aa)	12818	36.88	17.38	21.30	81.6	143	2.3
4933-14 (Sp)	2933-14aa x A	12703	35.67	17.83	21.70	82.1	116	1.3
Z431-18 (Sp)	Z131-18aa x A	14873	41.92	17.75	21.67	81.9	127	1.0
Z325-9	RZM Z225-9 (A,aa), (CZ25-9)	16084	42.47	19.13	23.07	82.8	132	1.0

TEST 1205. EVALUATION OF MULTIGERM PROGENY LINES, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	PM Score
Mulitgerm, S^f, Aa progeny lines (cont.)								
Z331-14	RZM Z131-14aa x A	14749	40.51	18.17	22.40	81.1	125	0.8
2930-35	RZM 1930-35aa x A, (C930-35)	14038	37.69	18.63	22.50	82.8	132	2.5
4930-229	Inc. 2930-35-229 (A,aa)	11873	33.26	17.88	22.48	79.5	141	1.8
Z425-214	Inc. Z225-214 (A,aa)	14147	37.89	18.65	22.48	83.0	143	3.5
4929-211	Inc. 2929-112-221 (A,aa)	11202	30.64	18.27	22.63	80.8	116	1.0
4929-227	Inc. 2929-112-227 (A,aa)(Fusaritium susc)	9562	27.18	17.65	21.52	82.0	98	0.3
4924-203	Inc. 2924-203 (A,aa)	10724	31.84	16.75	21.40	78.1	127	1.3
4942-202	Inc. 2942-202 (A,aa)	11741	33.86	17.30	21.35	81.1	125	0.0
4942-209	Inc. 2942-209 (A,aa)	15256	42.73	17.85	22.42	79.7	141	0.5
4942-211	Inc. 4942-211 (A,aa)	12207	34.26	17.83	22.10	80.7	123	0.0
2930-19	RZM 1930-19aa x A, (C930-19)	13961	40.11	17.40	21.25	81.9	120	0.8
3931-56	RZM 1931-56aa x A	14651	41.72	17.60	21.80	80.8	139	0.8
4954-213	Inc. 2954-213 (A,aa)	14170	42.33	16.73	20.73	80.7	116	1.8
4954-231	Inc. 2954-231 (A,aa)	14518	43.13	16.83	20.75	81.1	148	1.3
4954-207	Inc. 2954-207 (A,aa)	15474	45.55	16.98	20.73	81.9	145	3.3
4954-210	Inc. 2954-210 (A,aa)	14222	37.33	19.08	23.15	82.4	145	1.0
4952-202	Inc. 2952-202 (A,aa)	15619	42.93	18.20	22.48	81.0	130	2.3
CR410-231	Inc. CR210-14-2-231	9912	30.43	16.27	21.52	75.6	141	2.0
CR412-211	Inc. CR212-5-211	14204	40.71	17.45	21.55	81.0	145	2.0
CR412-5	Inc. CR212-5-211,212,216-218	13453	38.29	17.58	21.50	81.7	134	3.5
CR410-203	Inc. CR210-5-203	11958	33.64	17.77	22.67	78.4	116	2.3
CR311-88	Inc. CR111-88 (A,aa)	15554	46.36	16.77	21.02	79.8	139	2.8
Mean		14037.3	40.06	17.52	21.57	81.3	131.3	1.8
LSD (.05)		2418.1	6.77	0.84	0.80	3.1	26.7	1.1
C.V. (%)		12.3	12.08	3.44	2.64	2.7	14.5	44.0
F value		4.7**	4.61**	4.17**	5.28**	2.9**	1.6*	10.8**

Notes: See Test 2305 under rhizomania conditions.

TEST 105. PERFORMANCE OF LINES UNDER BYV INFECTION, SALINAS, CA, 2005

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: April 19, 2005
Harvested: October 6, 2005
BYV Inoc: June 14, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Loss %	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/100' No.	PM Score	Virus Yellows 8/05	Virus Yellows 8/29	Virus Yellows 9/15	Virus Yellows Mean
Hybrid checks												
Beta 4430R	Betaseed, 8/21/03	13149	20.7	37.98	17.30	84.0	146	3.1	4.8	4.3	5.4	4.8
Phoenix	Holly Hybrids, 9/12/03	11158	20.6	33.25	16.77	84.4	143	6.5	4.8	3.4	4.5	4.2
Y491H50	C790-15CMS x RZM Y391	11311	18.7	33.18	17.05	81.9	97	1.8	2.5	2.5	3.0	2.7
O.P. MM line checks												
03-SP22-0	Inc. 01-SP22-0	7838	34.2	25.24	15.41	80.4	142	3.3	5.6	5.5	6.1	5.8
03-US75	Inc. 00-US75	7973	28.3	26.76	14.88	79.1	143	9.0	4.3	4.3	5.5	4.7
04-C37	Inc. 03-C37	10184	15.7	30.58	16.61	81.7	137	8.5	3.1	2.6	3.4	3.0
R378	Inc. R178	10954	15.3	32.82	16.66	81.2	129	4.0	3.4	2.7	3.6	3.2
R376-89-4	Inc. R176-89-4	10157	1.8	30.14	16.84	80.7	139	3.3	1.8	1.3	1.8	1.6
MM lines												
481-22	RZM R181-22, C81-22	12485	5.1	35.93	17.39	81.3	148	3.5	2.5	2.1	3.0	2.5
R476-89	RZM-ER-% R276-89	10795	13.7	31.79	16.96	82.4	146	1.9	1.6	1.1	1.8	1.5
Z210	Inc. Z010(C),(Polish%S gp)	9972	24.8	26.11	19.05	82.1	130	5.9	4.5	4.4	5.3	4.7
R421	RZM-ER-% R221	12042	15.5	36.08	16.67	80.8	149	3.8	2.8	1.8	3.0	2.5
Y475	RZM-ER-% Y275	11299	15.7	33.70	16.77	82.6	149	2.8	2.9	2.5	2.9	2.8
Y491	RZM Y391	10113	22.1	30.30	16.70	80.9	86	1.6	2.4	2.3	3.3	2.6
Y369	RZM-ER-% Y169	12763	16.1	36.64	17.41	81.3	144	1.0	2.8	2.0	2.5	2.4
R380	RZM-ER-% R180	11399	21.4	32.80	17.38	82.5	141	2.5	3.1	2.6	3.6	3.1
P428	PMR-RZM P328, CP04	11452	26.1	35.22	16.27	81.5	140	1.3	3.6	2.9	3.8	3.4
N412(Sp)	N312,N212-#(C)aa x A, CN12	11140	25.1	33.83	16.48	81.8	127	0.9	2.0	2.1	3.0	2.4
P430	PMR-RZM P330, CP06	11600	23.2	35.02	16.56	81.0	142	1.4	2.5	2.0	2.9	2.5
MM,S^f,Aa populations												
4931	RZM 3931aa x A, C931	12229	13.7	35.58	17.16	82.1	123	2.1	3.0	2.6	3.6	3.1
4941	RZM 3941aa x A, C941	12425	18.1	35.94	17.27	82.0	135	2.1	3.0	2.6	3.8	3.1
3942	RZM 2942aa x A	11288	13.9	32.19	17.55	79.8	131	1.8	2.5	2.0	2.9	2.5
4943	RZM 3943aa x A	11601	22.0	32.65	17.74	82.6	145	2.0	3.4	2.9	3.5	3.3
mm,S^f,Aa populations												
4846m	T-O,RZM 3845,3846mmaa x A	9331	28.9	27.95	16.69	80.5	128	5.3	5.0	4.9	6.1	5.3

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Loss %	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/ 100' No.	PM Score	Virus Yellows 8/05	Virus Yellows 8/29	Virus Yellows 9/15	Virus Yellows Mean
Mean		11027.4		32.57	16.90	81.6	135.1	3.3	3.2	2.8	3.7	3.2
LSD (.05)		1030.8		2.71	0.55	1.9	15.2	1.1	0.6	0.5	0.6	0.4
C.V. (%)		9.5		8.46	3.32	2.4	11.4	32.9	19.2	18.3	15.6	13.3
F value		13.1**		12.51**	15.71**	3.0**	8.1**	34.2**	23.7**	37.5**	36.3**	
54.5**												

NOTES: Tests 105 and 505 are companion tests. Test 105 was inoculated June 14, 2005 with *Beet yellows virus* (BYV). %Loss is the relative sugar yield loss calculated from the corresponding means in each test. Inoculum was produced by H.-Y.Liu and J.L.Sears. A source of BYV was passed through *chenopodium captitatum* and from plants with severe vein clearing, transferred to sugarbeet plants used to produce viruliferous aphids for the field inoculation. BWYV and BChV could not be detected in the source plants or subsequently from plants inoculated in the field. Little natural VY infection appeared to occur.

Virus yellows foliar symptoms were scored on a scale of 0-9, where 9 = 90-100% of the mature leaf area yellowed. Scores were made on 8/05, 8/29, 9/15 by DP and JO.

At harvest, test 105 showed moderate rhizomania in susceptible entries, e.g., 03-SP22-0, 03-US75, 03-C37, 99-C46/2, 99-C31/6, and Z210.

Correlations within VY inoculated test 105

	SY	RY	%S	RJAP	% loss
BYV mean	-0.47*	-0.47*	-0.20NS	0.02NS	0.73**
BYV 8/05	-0.40NS	-0.40NS	-0.17NS	0.11NS	0.67**
BYV 8/29	-0.51*	-0.53**	-0.20NS	-0.02NS	0.74**
BYV 9/15	-0.47*	-0.47*	-0.21**	-0.03NS	0.74**
% sugar	0.53*	0.24NS		0.44*	-0.35NS
% loss	-0.49*	-0.43*	-0.35NS	-0.09NS	

Correlations between corresponding tests

VY Inoc.	Non-inoculated test (Test 505) SY	RY	%S	RJAP
SY	0.75**	0.61**	0.44*	0.60**
RY	0.74**	0.72**	0.15NS	0.49*
% sugar	0.34NS	-0.04NS	0.95**	0.50*
RJAP	0.54*	0.40NS	0.40NS	0.65**
% loss	0.20NS	0.30NS	-0.18NS	-0.00NS

TEST 205. PERFORMANCE OF PROGENY LINES SELECTED FOR VIRUS YELLOWS RESISTANCE, BYV INOCULATED, SALINAS, CA, 2005

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: April 19, 2005
Harvested: October 5, 2005
BYV Inoc: June 14, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Loss %	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/100' No.	PM Score	Virus Yellows 8/05	Virus Yellows 8/29	Virus Yellows 9/15	Virus Yellows Mean
Hybrid checks												
Checks												
03-SP22-0	Inc. 01-SP22-0	7961	31.8	24.99	16.02	79.7	132	3.5	5.6	5.4	5.9	5.6
R481-22	RZM R181-22, C81-22	11364	17.4	33.10	17.16	81.5	133	2.9	2.4	1.9	3.0	2.4
4930-229	Inc. 2930-35-229 (A,aa)	6844	39.5	20.61	16.58	78.5	137	3.6	4.6	3.8	5.5	4.6
Z210	Inc. Z010(C),(Polish%S gp)	9638	29.4	25.34	19.01	81.0	127	4.9	4.5	4.3	5.3	4.7
Parental source checks												
3942	RZM 2942aa x A	10818	15.3	32.23	16.75	78.6	133	1.3	2.8	2.3	3.8	2.9
Y390	Inc. Y190-#(C),C2,Syn 1	11208	23.2	33.59	16.67	81.2	139	4.8	3.1	2.0	3.3	2.8
CR411	RZM CR311aa x A,CR11	10824	21.6	33.71	16.04	79.5	130	4.1	3.3	2.8	4.0	3.3
Z425	RZM Z325aa x A,CZ25/2	10876	26.1	32.50	16.73	79.5	128	3.6	4.4	3.8	4.8	4.3
4931	RZM 3931aa x A,C931	11805	18.0	34.57	17.08	81.3	136	1.9	3.4	2.8	3.4	3.2
4941	RZM 3941aa x A,C941	12083	16.1	36.58	16.50	81.6	135	2.5	3.0	2.1	3.6	2.9
Inc. S_1 progeny												
4951-210	Inc. 2951-210 (A,aa)	7706	31.2	24.29	15.86	78.6	129	1.1	4.1	4.1	5.1	4.5
4952-202	Inc. 2952-202 (A,aa)	12394	15.5	35.89	17.26	80.9	132	5.0	2.1	1.6	2.9	2.2
4952-205	Inc. 2952-205 (A,aa)	9420	24.2	27.51	17.09	80.1	144	2.4	3.5	3.5	5.1	4.0
4952-212	Inc. 2952-212 (A,aa)	8785	24.6	26.15	16.79	80.1	141	6.1	2.6	1.8	2.8	2.4
4952-222	Inc. 2952-222 (A,aa)	8915	20.5	24.69	18.01	79.1	123	0.4	4.1	3.5	4.8	4.1
4953-209	Inc. 2953-209 (A,aa)	7479	27.7	22.55	16.60	79.0	115	0.1	2.9	2.1	3.6	2.9
4953-215	Inc. 2953-215 (A,aa)	8408	26.0	26.47	15.88	79.1	136	2.5	2.4	2.0	3.8	2.7
4953-217	Inc. 2953-217 (A,aa)	10423	20.8	31.48	16.58	81.8	146	1.8	0.9	1.0	1.1	1.0
4954-204	Inc. 2954-204 (A,aa)	9229	17.3	27.31	16.90	80.5	134	4.6	3.5	2.5	3.4	3.1
4954-207	Inc. 2954-207 (A,aa)	9385	32.1	29.08	16.13	80.7	132	5.8	2.9	2.5	3.8	3.0
4954-210	Inc. 2954-210 (A,aa)	9383	22.2	26.86	17.45	78.9	147	1.0	2.3	1.5	2.9	2.2
4954-225	Inc. 2954-225 (A,aa)	10437	17.2	31.94	16.33	78.8	136	1.0	2.5	2.0	2.4	2.3
4942-202	Inc. 2942-202 (A,aa)	9389	21.3	28.56	16.41	78.3	130	0.8	1.8	1.8	3.5	2.3
4942-211	Inc. 2942-211 (A,aa)	7633	30.0	23.13	16.50	77.9	123	0.1	3.3	2.6	4.1	3.3

TEST 205. PERFORMANCE OF PROGENY LINES SELECTED FOR VIRUS YELLOWS RESISTANCE, BYV INOCULATED, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Loss %	Beets Tons	Sucrose %	RJAP %	Beets/100' No.	PM Score	Virus Yellows 8/05	8/29	9/15	Mean
Mean		9683.6		28.88	16.76	79.84	133.2	2.7	3.2	2.6	3.8	3.2
LSD (.05)		886.8		2.42	0.59	2.10	15.6	1.2	0.6	0.5	0.7	0.4
C.V. (%)		9.3		8.50	3.55	2.67	11.9	42.5	18.1	20.1	18.8	13.5
F value		23.8**		27.38**	11.18**	2.48**	1.8NS	20.1**	26.7**	31.5**	19.1**	46.5**

NOTES: Tests 205 and 605 are companion tests. Test 205 was inoculated June 14, 2005 with *Beet yellows virus* (BYV). %Loss is the relative sugar yield loss calculated from the corresponding means in each test. Inoculum was produced by H.-Y.Liu and J.L.Sears. A source of BYV was passed through *chenopodium captitatum* and from plants with severe vein clearing, transferred to sugarbeet plants used to produce viruliferous aphids for the field inoculation. BWYV and BChV could not be detected in the source plants or subsequently from plants inoculated in the field. Little natural VY infection appeared to occur.

Virus yellows foliar symptoms were scored on a scale of 0-9, where 9 = 90-100% of the mature leaf area yellowed. Scores were made on 8/05, 8/29, 9/15 by DP and JO.

At harvest, test 205 showed moderate rhizomania.

Correlations within VY inoculated test 105

	SY	RY	%S	RJAP	% loss
BYV mean	-0.43*	-0.46*	0.10NS	-0.25NS	0.60**
BYV 8/05	-0.37NS	-0.41*	0.12NS	-0.18NS	0.54*
BYV 8/29	-0.40NS	-0.43*	0.09NS	-0.19NS	0.58**
BYV 9/15	-0.47*	-0.50*	0.08NS	-0.35NS	0.62**
% sugar	0.20NS	-0.04NS		0.28NS	-0.18NS
% loss	-0.78**	-0.74**	-0.18NS	-0.35NS	

Correlations between corresponding tests

VY Inoc.	Non-inoculated test (Test 505) SY	RY	%S	RJAP
SY	0.88**	0.82**	0.05NS	0.15NS
RY	0.86**	0.89**	-0.17NS	0.16NS
% sugar	0.17NS	-0.19NS	0.90**	-0.01NS
RJAP	0.67**	0.61**	0.09NS	0.47*
% loss	-0.39NS	-0.37NS	0.00NS	0.09NS

TEST 4105. PERFORMANCE OF LINES & POPULATIONS UNDER RHIZOMANIA, SALINAS, CA, 2005

48 entries x 8 reps., RCB (e)
1-row plots, 22 ft. long

Planted: May 4, 2005
Harvested: October 17, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/ 100' No.	PM Score	Root Rot %	Bolting %	Foliar Score
Hybrid checks										
Acclaim	3/15/05	4869	15.82	15.30	78.6	158	2.9	4.7	2.1	2.0
Beta 4430R	8/21/03	7062	21.78	16.30	80.0	185	1.1	0.9	0.3	2.0
Angelina	2/25/04	9559	28.07	17.05	81.2	176	5.0	0.7	0.0	1.5
Roberta	2/25/04	4694	15.95	14.71	78.1	182	1.9	2.2	0.9	3.1
Beta G017R	Rz2 hybrid, 7/22/04	9906	29.23	16.96	81.4	195	1.8	2.0	0.0	1.3
MM,O.P. lines										
04-C37	Inc. 03-C37	5015	16.08	15.65	79.9	186	5.1	1.8	0.0	2.4
R378 Sp	RZM R178, (C78/3)	7263	21.50	16.86	81.5	174	2.3	0.3	0.0	1.5
R437	RZM-% R637,R337, (C79-9)	6341	19.33	16.36	81.5	198	3.8	1.9	0.0	2.0
R481-22	RZM R181-22, C81-22	7650	22.77	16.84	81.4	187	1.9	1.8	0.0	1.5
R476-89	RZM-ER-% R276-89	7022	20.86	16.81	81.1	176	1.8	1.2	0.0	1.4
Z210	Inc. Z010(C), Polish %S gp	4820	14.17	17.00	81.7	165	3.1	3.4	1.2	3.3
R421	RZM-ER-% R221	9569	30.31	15.79	80.0	188	2.1	2.0	0.3	1.4
Y475	RZM-ER-% Y275	8818	27.46	16.05	80.8	181	2.0	1.6	0.4	1.1
Y491	RZM Y391	7086	21.05	16.89	81.1	148	1.9	1.8	0.8	1.6
Y369	RZM-ER-% Y169	7553	22.20	17.06	80.9	178	1.1	0.3	0.3	2.0
R380	RZM-ER-% R180	7760	23.73	16.36	80.8	187	1.5	0.9	0.0	1.6
N472 (Sp)	N372, N272-#(C)aa x A, CN72	9280	28.82	16.11	80.2	179	1.4	1.9	0.0	1.1
N412 (Sp)	N312, N212-#(C)aa x A, CN12	9380	28.79	16.29	80.6	169	0.9	1.1	0.7	1.3
P427	PMR-RZM P327, CP03	5851	18.16	16.06	80.7	168	1.3	2.8	1.9	1.9
P428	PMR-RZM P328, CP04	7921	24.85	15.96	80.7	177	1.3	1.5	0.3	1.8
P429	PMR-RZM P329, CP05	7516	23.53	15.90	80.3	188	0.8	4.7	0.3	1.9
P430	PMR-RZM P330, CP06	8743	26.88	16.24	80.7	178	1.1	3.0	0.0	1.3
P407/8	PMR-RZM-% P207/8, CP08	9608	29.48	16.29	80.6	186	1.4	2.3	0.0	1.4
P418-6	PMR-RZM P318-6(Iso), CP07	7456	23.44	15.91	80.6	184	1.4	0.0	0.0	1.4

TEST 4105. PERFORMANCE OF LINES & POPULATIONS UNDER RHIZOMANIA, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/100' No.	PM Score	Root Rot %	Bolting %	Foliar Score
MM,O.P. lines (cont.)										
P431CT	RZM,CTR R278, P230, P207/8	7740	22.71	17.06	81.6	190	1.0	0.8	0.0	1.8
K402	RKNR M6-2	6358	20.10	15.81	80.2	174	1.0	1.9	0.0	1.1
K403	RKNR M1-3, -3a	8132	25.68	15.81	79.6	180	3.3	3.3	0.0	1.1
K404	RKNR M1-4	7024	21.57	16.29	80.5	176	2.4	0.7	0.0	1.6
Y477	RZM-ER-% Y277	8535	26.30	16.27	80.8	191	2.4	0.9	0.0	1.4
Y492	RZM-ER-% Y292	8494	25.16	16.89	81.5	188	2.8	0.3	0.0	1.4
Y390	Inc. Y190-#(C), C2, Syn 1	7303	21.72	16.80	81.2	185	2.3	2.9	0.0	1.4
Y393	Inc. FS-#'s, C1, Syn 1	8408	25.30	16.61	80.9	175	1.6	2.5	0.0	1.5
MM,S^f,Aa populations										
04-FC1028	RZM-% FC20021028,(FC709/2 x 9933)	5925	18.78	15.79	80.1	174	1.9	1.6	1.7	1.8
04-FC1037	RZM-% FC20021037,(FC·LSR x EL·LSR) x CR11	6960	21.18	16.42	80.8	185	2.9	0.6	0.0	1.8
04-FC1038	RZM-% FC20021038,(FC·LSR x EL·LSR) x CR10	7536	23.44	16.13	81.0	176	3.0	0.3	0.4	2.0
4921	RZM-ER-% 2921	8242	25.29	16.27	80.7	196	2.4	0.6	0.0	1.1
3942	RZM 2942aa x A	7237	21.68	16.67	81.3	194	1.8	0.9	0.0	1.6
4943	RZM 3943aa x A	8187	23.96	17.08	81.6	185	1.8	0.3	0.0	1.6
Z425	RZM Z325aa x A, CZ25/2	7212	21.77	16.56	80.7	180	2.5	0.3	0.0	1.5
CR411	RZM CR311aa x A, CR11	7464	23.01	16.23	80.4	178	2.6	0.3	0.3	1.6
4931	RZM 3931aa x A, C931	7970	24.20	16.54	81.1	173	1.6	2.5	0.6	1.6
4941	RZM 3941aa x A, C941	8215	24.87	16.60	80.7	178	1.3	0.4	0.0	1.4
N412 (Iso)	PMR-RZM N312 (A,aa)	8609	27.16	15.88	80.2	187	1.0	2.2	0.0	1.5
N472 (Iso)	RZM-NR N372 (A,aa)	8880	27.62	16.06	80.4	178	1.0	0.6	0.3	1.5
R425	RZM-% R725, R325, (C79-3, WB42)	5805	18.14	16.01	81.1	182	4.4	2.7	2.0	2.1

TEST 4105. PERFORMANCE OF LINES & POPULATIONS UNDER RHIZOMANIA, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/ 100' No.	PM Score	Root Rot %	Bolting %	Foliar Score
mm,S^f,Aa populations										
4843m	RZM,T-O 3843-#(C)mmaa x A	4729	14.26	16.48	81.0	153	2.4	0.7	3.8	2.8
4891m	RZM,T-O 3891-#(C)mmaa x A	5802	17.71	16.39	80.8	157	2.4	0.3	1.5	2.4
4846m	RZM,T-O 3845,3846-#(C)mmaa x A	6056	18.99	16.06	80.3	176	3.1	0.0	0.0	2.1
Mean		7449.2	22.81	16.32	80.7	179.3	2.1	1.5	0.4	1.7
LSD (.05)		1113.0	3.38	0.53	0.7	18.7	0.7	3.1	1.7	0.6
C.V. (%)		15.2	15.06	3.27	0.9	10.6	33.3	210.3	412.4	34.1
F value		12.0**	11.55**	6.87**	7.5**	2.5**	16.8**	1.1NS	1.6*	5.5**

NOTES: Performance in Tests 4105, 4205, and 4305-1 suggested that mixed strains of BNYVV occurred. That is, mixed between normal-Spence-BNYVV and resistance-breaking-strains of BNYVV. With only normal-BNYVV, Beta 4430R would have had equal or better yield than Angelina and Beta G017R.

The relative performance between lines with known resistance to SBCN (e.g. CN12 & CN72) and those without SBCN resistance also suggested SBCN were present and affecting performance.

K402, K403 & K404 were increases from Dr. Yu's program on introgressing resistance to RKN (*Meloidogyne* spp.) into sugarbeet.

Also see tests 105 under BYV inoculated conditions and 505 under disease free conditions. As might be expected, the CV's for the non-diseased trials were much lower than for the rhizomania trials.

TEST 4205. RHIZOMANIA EVALUATION OF SOURCES OF RESISTANCE, SALINAS, CA, 2005

12 entries x 8 reps, RCB
1-row plots, 22 ft. long

Planted: May 4, 2005
Harvested: November 14, 2005

Variety	RZM Resist	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Beets/100' No.	RJAP %	Foliar Color Score	Root Rot %	PM Score
04-C37	--	Inc. 03-C37	5094	16.22	15.71	19.51	188	80.6	3.1	1.0	5.4
R340	C79-#'s	RZM-ER-% R140	9337	28.88	16.14	19.85	192	81.3	1.3	0.0	1.4
R424	C79-2,WB41	RZM-% R724,R324	6898	21.63	15.91	20.40	196	78.0	2.6	2.3	4.8
R425	C79-3,WB42	RZM-% R725,R325	6628	19.81	16.81	19.98	177	84.3	2.6	2.3	5.1
Beta G017R	*Rz2*	7/22/04	10290	29.64	17.41	21.09	202	82.6	1.1	1.4	0.6
Beta 4430R	*Rz1*	Resist. check	8275	24.39	16.99	19.89	202	85.4	2.6	1.2	0.9
Roberta	--	Susc.ck, 2/25/04	3773	12.97	14.44	17.96	173	80.8	4.1	2.3	1.5
Angelina	*Rz1* & *Rz2*	Resist. check	10540	29.69	17.75	21.02	176	84.4	1.5	1.4	5.8
R421	*Bvm*	RZM-ER-% R221	9336	28.26	16.51	20.04	201	82.5	1.5	0.9	1.1
R039	Q	Inc. R539 (C39R)	7435	22.10	16.90	20.72	168	81.6	2.0	1.1	0.4
Y477	R22	RZM-ER-% Y277	9874	29.22	16.84	20.01	199	84.1	1.8	0.9	1.6
Y492	*Rz1*+	RZM-ER-% Y292	9653	28.07	17.17	20.61	201	83.4	1.8	1.4	2.3
Mean			8094.5	24.24	16.55	20.09	189.6	82.4	2.2	1.4	2.6
LSD (.05)			1467.3	4.28	0.64	0.80	19.3	3.6	0.5	2.7	1.1
C.V. (%)			18.2	17.75	3.90	3.97	10.2	4.4	24.5	201.3	41.3
F value			17.1**	14.10**	15.34**	8.69**	3.5**	2.7*	22.1**	0.5NS	30.1**

Test 4205 was grown at Spence field under supposed normal BNYVV conditions. Except the location where 4205 and part of 4305 were growing produced beet growth and foliar symptoms as if there may have been a resistance-breaking strain of BNYVV present. The canopy (visual yellowing) of Beta4430R suggested that it was moderately susceptible, unlike in test 4405, for example. Dr. Liu tested soil from an area near test 4205 and based on greenhouse results, a resistance-breaking strain may be present. The relationship of this strain to IV-BNYVV is not yet determined. Root scores for test 4205 were not made. Other soilborne factors may have occurred.

See tests 6205, 6405, 4405, 4305, 4105, and others.

TEST 2305. EVALUATION OF MULTIGERM PROGENY LINES UNDER RHIZOMANIA, SALINAS, CA, 2005

48 entries x 4 reps., sequential
1-row plots, 11 ft. long

Planted: May 3, 2005
Harvested: November 16, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	PM Score
Checks									
Angelina	2/25/04	13903	36.49	19.02	22.77	83.5	184	0.0	4.8
Roberta	2/25/04	5553	17.13	16.18	19.65	82.3	184	2.3	3.0
Beta 4430R	8/21/03	12403	34.07	18.17	22.02	82.5	189	0.0	2.3
Acclaim	3/15/05	10264	30.64	16.75	20.10	83.3	173	1.2	5.5
04-C37	Inc. 03-C37	5383	15.72	17.10	21.50	79.6	189	0.0	5.8
R424	RZM-% R724,R324, (C79-2)	7919	23.38	16.95	22.15	76.6	193	0.0	4.8
R425	RZM-% R725,R325, (C79-3)	7789	23.38	16.75	21.72	77.1	200	0.0	5.0
R424/5	RZM-% R824,R324/5	7894	22.58	17.45	22.47	77.6	214	0.0	4.0
R437	RZM-% R637,R337, (C79-9)	8347	24.39	17.15	22.47	76.3	207	1.1	5.0
R336	RZM-ER-% R136, (C79-8)	9656	28.02	17.25	22.27	77.5	180	0.0	3.8
P418-6	PMR-RZM P318-6(Iso), (CP08)	10012	29.43	17.00	22.47	75.7	182	0.0	1.3
P407/8	PMR_RZM-% P207/8, (CP07)	12520	34.67	18.02	22.90	78.8	191	1.3	1.3
P428	PMR-RZM P328, (CP04)	11035	31.24	17.65	21.83	80.9	182	0.0	1.3
P430	PMR-RZM P330, (CP06)	10729	30.24	17.73	22.82	77.6	184	0.0	1.0
N412(Sp)	N312,N212-#(C)aa x A, (CN12)	11520	32.66	17.67	22.45	78.8	193	0.0	1.5
N472(Sp)	N372,N272-#(C)aa x A, (CN72)	11227	33.66	16.67	21.35	78.0	193	0.0	2.8
Multigerm, O.P. Progeny lines									
R480-6(Sp)	RZM R280-6	8608	24.39	17.67	22.20	79.7	157	0.0	2.0
R481-22	RZM R181-22, (C81-22)	11350	30.84	18.40	22.65	81.3	184	0.0	2.3
R476-89	RZM-ER-% R276-89	9574	26.00	18.42	23.00	80.1	193	0.0	1.8
R480-6(Iso)	RZM R280-6	9964	28.22	17.65	22.00	80.2	173	0.0	2.3
Multigerm, S^f,Aa progeny lines									
4941-20(Sp)	2941-20aa x A	9593	27.82	17.25	21.60	79.9	161	0.0	1.5
4941-20(Iso)	RZM 2941-20 (A,aa)	10298	29.43	17.48	22.13	79.0	184	0.0	1.0
4933-14(Iso)	RZM 2933-14 (A,aa)	7973	22.17	17.97	22.58	79.6	195	0.0	1.0
4933-14(Sp)	2933-14aa x A	9218	25.00	18.48	23.15	79.8	166	0.0	1.0

TEST 2305. EVALUATION OF MULTIGERM PROGENY LINES UNDER RHIZOMANIA, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	PM Score
Multigerm, S^f,Aa progeny lines (cont.)									
Z431-18(Sp)	Z131-18aa x A	10055	26.81	18.75	23.88	78.6	168	0.0	1.0
Z325-9	RZM Z225-9 (A,aa), (CZ25-9)	10283	26.20	19.58	23.55	83.1	166	1.7	1.3
Z331-14	RZM Z131-14aa x A	9716	26.41	18.42	23.25	79.3	195	1.3	2.0
2930-35	RZM 1930-35aa x A, (C930-35)	10779	28.62	18.83	23.42	80.4	175	2.6	3.8
4930-229	Inc. 2930-35-229 (A,aa)	7178	21.37	16.90	22.25	75.9	173	0.0	1.3
Z425-214	Inc. Z225-214 (A,aa)	7047	19.75	17.80	22.75	78.3	189	2.4	4.0
4929-211	Inc. 2929-112-221 (A,aa)	7863	20.96	18.77	24.20	77.6	184	0.0	1.0
4929-227	Inc. 2929-112-227 (A,aa)(Fusatium susc.)	3620	9.68	18.88	23.47	80.4	116	0.0	1.0
43924-203	Inc. 2924-203 (A,aa)	10044	28.42	17.67	22.55	78.4	173	0.0	1.3
4942-202	Inc. 2942-202 (A,aa)	8467	23.79	17.77	22.70	78.4	189	0.0	1.0
4942-209	Inc. 2942-209 (A,aa)	10798	29.83	18.15	23.83	76.2	195	0.0	1.0
4942-211	Inc. 4942-211 (A,aa)	7846	22.58	17.35	22.85	75.9	180	0.0	1.0
2930-19	RZM 1930-19aa x A, (C930-19)	10201	29.63	17.23	22.10	77.9	173	0.0	1.3
3931-56	RZM 1931-56aa x A	11250	31.45	17.90	21.58	83.1	182	0.0	1.5
4954-213	Inc. 2954-213 (A,aa)	10391	29.43	17.67	22.15	79.8	173	0.0	3.3
4954-231	Inc. 2954-231 (A,aa)	11314	32.05	17.65	21.77	81.1	193	0.0	2.3
4954-207	Inc. 2954-207 (A,aa)	10019	29.23	17.15	21.90	78.3	200	0.0	3.8
4954-210	Inc. 2954-210 (A,aa)	8767	22.98	19.08	23.95	79.7	184	0.0	1.3
4952-202	Inc. 2952-202 (A,aa)	6608	18.14	17.77	22.13	80.3	195	0.0	3.0
CR410-231	Inc. CR210-14-2-231	6254	18.54	16.98	22.45	75.7	155	0.0	2.0
CR412-211	Inc. CR212-5-211	9101	27.62	16.55	22.52	73.5	177	0.0	3.3
CR412-5	Inc. CR212-5-211,212-216,218	8003	23.79	16.90	22.05	76.6	189	3.8	4.5
CR410-203	Inc. CR210-5-203	6054	17.54	17.13	23.30	73.5	177	0.0	3.3
CR311-88	Inc. CR111-88 (A,aa)	10338	31.45	16.42	20.60	79.7	168	1.2	4.3
Mean		9265.2	26.21	17.67	22.41	78.9	181.6	0.4	2.5
LSD (.05)		1822.5	4.95	1.06	1.06	3.5	28.4	2.4	0.9
C.V. (%)		14.1	13.52	4.29	3.39	3.1	11.2	435.4	26.2
F value		9.8**	9.78**	4.14**	5.69**	3.7**	2.4**	1.0NS	20.3**

NOTES: See Test 1205 under non-diseased conditions.

TEST 2405. PERFORMANCE OF PROGENY LINES UNDER RHIZOMANIA SELECTED FOR VIRUS YELLOWS RESISTANCE, SALINAS, CA, 2005

24 entries x 4 reps., sequential
1-row plots, 11 ft. long

Planted: May 3, 2005
Harvested: November 17, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	PM Mean
Checks									
Z325-9	RZM Z225-9 (A,aa), (CZ25-9)	10447	27.84	18.75	23.42	80.1	164	0.0	1.4
Roberta	2/25/04	5725	19.40	14.88	19.03	78.2	164	1.3	1.6
4930-229	Inc. 2930-35-229 (A,aa)	7463	22.92	16.33	22.35	73.0	164	0.0	1.1
Z210	Inc. Z010(C), (Polish %S gp)	6703	16.95	19.73	24.20	81.5	173	1.3	2.9
Parental source checks									
3942	RZM 2942aa x A	10178	28.70	17.73	22.80	77.8	182	0.0	1.3
Y390	Inc. Y190-#(C),C2,Syn1	10793	29.99	18.00	23.25	77.4	191	2.4	2.9
CR411	RZM CR311aa x A, CR11	10101	29.83	16.92	21.63	78.4	175	0.0	3.0
Z425	RZM Z325aa x A, CZ25/2	9999	28.22	17.77	23.27	76.4	189	0.0	2.6
4931	RZM 3931aa x A, C931	10897	31.37	17.35	22.13	78.5	168	0.0	1.9
4941	RZM 3941aa x A, C941	10100	29.23	17.33	22.13	78.3	182	0.0	1.8
Inc. S_1 progeny									
4951-210	Inc. 2951-210 (A,aa)	9017	25.62	17.60	22.88	76.9	175	0.0	1.5
4952-202	Inc. 2952-202 (A,aa)	9821	28.24	17.45	22.02	79.3	175	1.3	1.5
4952-205	Inc. 2952-205 (A,aa)	9411	26.41	17.83	23.95	74.4	191	1.3	1.4
4952-212	Inc. 2952-212 (A,aa)	8167	24.59	16.60	21.35	77.8	170	1.3	3.1
4952-222	Inc. 2952-222 (A,aa)	8171	22.25	18.40	24.60	74.7	186	0.0	1.5
4953-209	Inc. 2953-209 (A,aa)	8744	23.79	18.40	23.45	78.5	161	1.4	0.5
4953-215	Inc. 2953-215 (A,aa)	10657	30.34	17.50	22.70	77.2	186	0.0	1.9
4953-217	Inc. 2953-217 (A,aa)	8612	25.72	16.80	21.82	77.0	173	1.3	1.0
4954-204	Inc. 2954-204 (A,aa)	10501	29.97	17.52	21.88	80.1	195	0.0	2.5
4954-207	Inc. 2954-207 (A,aa)	9223	26.94	17.13	21.07	81.3	200	0.0	3.3

TEST 2405. PERFORMANCE OF PROGENY LINES UNDER RHIZOMANIA SELECTED FOR VIRUS YELLOWS RESISTANCE, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	PM Mean
Inc. S_1 progeny (cont.)									
4954-210	Inc. 2954-210 (A,aa)	8843	23.18	19.13	24.00	79.6	191	0.0	1.0
4954-225	Inc. 2954-225 (A,aa)	9641	26.20	18.40	22.10	83.2	189	0.0	0.8
4942-202	Inc. 2942-202 (A,aa)	7902	23.48	16.85	22.38	75.4	173	0.0	0.5
4942-211	Inc. 2942-211 (A,aa)	7663	22.21	17.25	22.58	76.4	168	0.0	0.8
Mean		9115.7	25.98	17.57	22.54	78.0	178.5	0.5	1.7
LSD (.05)		1987.3	5.71	1.03	1.01	4.0	26.0	2.5	0.7
C.V. (%)		15.5	15.58	4.16	3.19	3.6	10.3	363.3	29.2
F value		3.7**	3.30**	7.34**	10.98**	2.8**	1.5NS	0.7NS	11.6**

TEST 2605. PROGENY PERFORMANCE OF N412-#'s & N472-#'s UNDER SBCN AND RHIZOMANIA, SALINAS, CA, 2005

96 entries x 3 reps., sequential
1-row plots, 11 ft. long

Planted: May 3, 2005
Harvested: November 15, 2005

Variety	Resistance	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	DI %	%R (0-3) %	%R (0-4) %	Foliar Color Score	Root Rot %	PM Score
Checks													
Beta 4430R	*Rz*	Resist. *Rz* check, 8/21/03	10997	29.97	18.33	20	19	3.3	64.2	79.6	2.0	0.0	2.7
Phoenix	*Rz*	Resist. *Rz* check, 9/12/03	9270	26.71	17.47	18	17	4.0	45.2	66.8	2.0	0.0	5.0
US H11	--	Susc. check, 10/4/02	4146	13.08	15.90	21	21	6.5	13.1	20.6	4.7	0.0	5.3
Roberta	--	Susc. check, 2/25/04	3733	11.12	15.67	18	10	6.7	4.4	25.6	5.0	6.3	1.7
1927-4H5	*Rz*, R22	C833-5HO x RZM 9927-4 (C927-4)	11814	33.86	17.50	20	20	3.5	70.1	83.4	1.3	0.0	5.7
P418-6	*Rz*,WB242,R22	PMR-RZM P318-6(Iso) (CP08)	7190	21.90	16.37	20	21	4.8	28.1	50.2	1.7	0.0	0.7
P407/8	*Rz*, WB242	PMR-RZM-% P207/8 (CP07)	10908	29.91	18.20	19	18	3.7	50.9	80.1	2.0	0.0	1.3
Y475	*Rz*, R22	RZM-ER-% Y275	9756	26.47	18.40	18	19	3.3	69.5	89.4	1.3	0.0	2.3
N412(Sp)	WB242	N212-#(C), N312aa x A	9809	28.76	17.07	17	21	4.2	49.7	65.7	2.0	2.0	1.0
N412(Iso)	WB242	PMR-RZM N312 (A,aa)	10704	30.51	17.50	20	20	3.7	53.1	75.1	1.3	0.0	1.3
N412-6	WB242	Inc. N212-6	1368	4.18	16.47	20	18	7.8	1.8	4.0	5.3	3.9	1.3
N412-10	WB242	Inc. N212-10	7265	20.52	17.80	16	18	4.9	14.5	48.4	3.7	2.4	0.7
N412-11	WB242	Inc. N212-11	7882	21.93	17.83	17	18	4.8	14.6	57.6	2.7	0.0	0.0
N412-13	WB242	Inc. N212-13	3496	9.81	17.83	19	18	7.1	0.0	0.0	2.3	5.2	0.3
N412-202	WB242	Inc. N212-202	6739	19.67	17.17	15	13	4.8	38.8	54.7	3.7	11.9	1.7
N412-203	WB242	Inc. N212-203	7239	21.43	16.97	17	17	4.6	32.7	60.1	2.3	4.8	0.3
N412-205	WB242	Inc. N212-205	6436	17.48	18.40	17	18	5.0	26.7	50.0	3.0	0.0	1.7
N472(Sp)	*Bvm*	N272-#(C), N372aa x A	9894	27.23	18.27	18	19	3.9	46.3	69.2	2.3	3.5	2.7
N472(Iso)	*Bvm*	RZM-NR N372 (A,aa)	9153	26.61	17.27	17	19	3.4	71.5	91.4	2.0	0.0	1.3
N472-230	*Bvm*	Inc. N272-230	5126	15.48	16.60	14	13	4.2	43.8	64.8	3.0	15.6	3.3

TEST 2605. PROGENY PERFORMANCE OF N412-#'s & N472-#'s UNDER SBCN AND RHIZOMANIA, SALINAS, CA, 2005 (cont.)

Variety	Resistance	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	DI %	%R (0-3) %	%R (0-4) %	Foliar Color Score	Root Rot %	PM Score
Checks (cont.)													
N472-231	*Bvm*	Inc. N272-231	9423	27.56	17.10	16	18	3.7	62.3	77.5	1.3	0.0	2.0
N472-233	*Bvm*	Inc. N272-233	3417	10.06	16.93	15	10	8.2	0.0	0.0	4.3	8.3	1.3
4927-202	*Rz*, R22	Inc. 2927-4-202 (A,aa)	6308	19.57	16.17	17	15	4.6	33.3	49.3	1.7	3.7	3.0
US H11	--	Susc. check, 10/4/02	4236	12.63	16.77	20	20	5.8	18.7	38.2	4.0	0.0	6.0
N412-11H5	*Rz*, WB242	2833-5HO x N212-11	11141	30.24	18.43	17	18	3.2	79.4	96.7	1.3	0.0	1.3
N412-13H5	*Rz*, WB242	2833-5HO x N212-13	11579	32.92	17.47	21	22	3.4	61.6	89.4	2.0	0.0	0.7
N412-202H5	*Rz*, WB242	2833-5HO x N212-202	10016	27.15	18.47	20	22	3.4	67.8	83.3	1.7	0.0	2.7
N412-203H5	*Rz*, WB242	2833-5HO x N212-203	11946	33.06	18.07	21	22	3.2	68.5	94.1	1.0	0.0	0.3
N412-205H5	*Rz*, WB242	2833-5HO x N212-205	9520	25.43	18.70	20	21	3.9	47.1	73.1	1.7	0.0	4.3
N472-230H5	*Rz*, *Bvm*	2833-5HO x N272-230	10661	31.04	17.17	18	17	3.7	48.8	80.0	1.7	0.0	4.0
N472-231H5	*Rz*, *Bvm*	2833-5HO x N272-231	9292	27.09	17.13	9	9	3.5	55.7	81.5	1.7	0.0	2.0
N472-233H5	*Rz*, *Bvm*	2833-5HO x N272-233	12189	34.27	17.80	15	15	2.9	77.9	97.6	1.3	0.0	3.7
S_3 or S_n lines from N12													
N412-2 -401	WB242	N212-2⊗	7300	22.11	16.47	9	10	4.3	42.6	55.6	2.3	0.0	1.0
-402			7845	22.87	17.20	11	11	4.2	36.3	71.8	1.7	2.8	1.3
-403			8229	24.03	17.10	11	12	4.6	8.6	45.7	3.0	0.0	0.7
-404			6295	18.77	16.93	12	14	4.6	40.7	66.0	2.0	0.0	0.3
N412-8 -407	WB242	N212-8⊗	6795	19.91	17.17	13	14	5.8	14.8	30.0	2.0	0.0	3.0
-411			7252	21.26	17.07	12	12	5.2	17.4	42.0	2.0	2.8	4.7
-412			6878	20.43	16.87	16	16	4.5	44.2	66.1	1.3	0.0	5.3
-413			7044	21.35	16.50	13	12	4.7	15.0	46.3	2.0	2.8	4.0
N412-17 -415	WB242	N212-17⊗	6925	20.29	17.17	12	12	4.1	34.9	71.1	3.3	9.1	0.7
-416			8518	26.23	16.27	11	11	3.8	44.4	86.7	3.7	0.0	0.3
-417			7427	22.12	16.77	11	11	3.7	39.1	90.0	3.0	0.0	0.0
-418			8415	25.93	16.50	13	14	3.5	55.4	88.5	3.0	2.8	0.0

TEST 2605. PROGENY PERFORMANCE OF N412-#'s & N472-#'s UNDER SBCN AND RHIZOMANIA, SALINAS, CA, 2005
(cont.)

Variety	Resistance	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	DI %	%R (0-3) %	%R (0-4) %	Foliar Color Score	Root Rot %	PM Score
S_3 or S_n lines from N12 (cont.)													
N412-19 -423	WB242	N212-19⊗	6684	18.51	18.07	11	8	3.8	60.2	68.0	1.3	0.0	2.0
-424			7827	21.80	17.93	11	10	3.4	59.0	84.4	1.0	4.2	2.7
-427			8018	23.14	17.43	8	8	3.6	65.8	89.2	2.0	0.0	4.7
-428			6037	16.90	17.93	8	7	3.4	65.3	96.3	2.0	0.0	1.3
N412-22 -431	WB242	N212-22⊗	5605	16.52	16.90	15	16	5.0	6.3	37.2	3.3	0.0	0.0
-432			5636	17.75	16.57	14	15	5.0	12.6	42.6	2.3	0.0	0.0
-433			4380	11.48	18.70	12	12	4.7	19.4	41.8	3.3	2.6	0.7
-434			3988	13.15	15.23	13	14	5.3	6.7	25.1	4.0	0.0	0.7
N412-201 -438	WB242	N212-201⊗	5582	15.72	17.70	13	11	4.4	31.5	66.5	2.7	2.4	0.7
-439			6934	18.46	18.93	12	13	4.8	29.6	43.0	2.7	0.0	3.3
-440			5272	15.32	17.27	17	17	5.5	20.7	37.0	2.3	3.5	2.3
-441			7942	26.98	14.43	11	11	3.1	83.1	91.5	2.7	6.1	1.7
N412-204 -446	WB242	N212-204⊗	8723	26.06	16.77	13	14	4.5	30.5	55.9	2.0	7.7	0.7
-447			6068	18.86	16.07	14	12	5.8	13.9	28.3	3.0	9.7	1.3
-450			7395	23.28	15.90	15	12	4.7	22.5	58.3	3.3	3.7	0.7
04-C37		Inc. 03-C37	4477	13.38	16.67	20	17	5.7	19.8	28.7	3.7	1.7	7.0
N412-206 -452	WB242	N212-206⊗	6263	19.08	16.40	13	11	4.0	53.3	79.4	2.0	16.1	4.3
-453			6723	20.22	16.67	13	12	4.9	34.8	48.4	2.3	2.4	3.0
-454			10350	31.25	16.57	13	14	3.4	67.2	80.2	1.3	0.0	3.3
-455			6896	21.50	16.03	16	16	3.9	55.8	78.2	1.7	1.8	4.3
N412-207 -459	WB242	N212-207⊗	8864	23.83	18.60	9	9	4.5	20.9	65.7	1.7	3.0	1.3
-460			9403	26.85	17.53	9	9	3.7	54.1	74.8	2.0	0.0	0.3
-463			9624	27.33	17.67	7	8	5.4	24.3	37.6	1.3	0.0	4.0
4747		Inc. 0747 (A,aa)	5683	17.40	16.40	18	16	5.5	22.9	39.6	4.3	10.1	6.0

TEST 2605. PROGENY PERFORMANCE OF N412-#'s & N472-#'s UNDER SBCN AND RHIZOMANIA, SALINAS, CA, 2005 (cont.)

Variety	Resistance	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	DI %	%R (0-3) %	%R (0-4) %	Foliar Color Score	Root Rot %	PM Score
S_3 or S_n lines from N72													
Checks													
N412(Sp)	WB242	N212-#(C), N312aa x A	10055	29.56	17.00	19	19	4.0	48.4	73.0	2.0	1.7	1.7
N412(Iso)	WB242	PMR-RZM N312 (A,aa)	10336	29.90	17.33	18	17	3.8	56.7	78.2	1.7	0.0	0.7
N472(Sp)	*Bvm*	N272-#(C), N372aa x A	9734	26.54	18.40	20	20	4.6	38.8	55.6	1.3	1.7	2.3
N472(Iso)	*Bvm*	RZM-NR N372 (A,aa)	9699	27.82	17.43	19	19	4.2	59.3	73.8	2.0	0.0	2.0
N472-1 -401	*Bvm*	N272-1⊗	4109	12.84	16.03	9	9	7.5	10.0	10.0	3.7	0.0	5.7
-402			4204	13.96	15.37	10	8	7.8	0.0	2.8	2.3	0.0	5.7
-403			4674	14.36	16.27	12	14	7.5	7.7	10.3	3.0	0.0	6.7
-404			3795	11.57	16.20	15	14	7.5	2.4	7.9	4.3	0.0	6.0
N472-2 -409	*Bvm*	N272-2⊗	4541	14.78	15.33	14	15	7.9	0.0	4.8	3.0	0.0	6.3
-410			4363	13.51	16.13	14	15	7.3	2.1	4.3	2.0	0.0	6.3
-411			5017	15.45	16.23	15	14	6.7	7.0	22.9	1.7	0.0	6.0
-412			5614	17.11	16.40	11	11	6.6	12.3	17.9	2.0	0.0	5.7
N472-6 -417	*Bvm*	N272-6⊗	4653	13.14	17.73	12	10	7.4	12.5	16.7	2.3	0.0	4.3
-418			3621	11.54	15.67	13	14	6.1	22.6	42.1	2.0	0.0	5.7
-419			4445	13.32	16.83	11	11	6.9	8.3	17.3	2.3	0.0	5.3
-420			3343	10.04	16.73	12	10	6.9	15.0	35.6	2.3	10.5	5.0
N472-221 -425	*Bvm*	N272-221⊗	6112	20.37	15.00	15	16	4.6	52.4	63.5	3.3	0.0	1.0
-426			6281	20.38	15.50	15	18	4.3	40.5	78.0	3.3	1.9	1.7
-427			8027	25.40	15.83	13	16	3.3	78.1	83.8	2.7	0.0	1.3
-428			4440	15.04	14.73	13	13	6.4	25.7	36.8	3.7	0.0	1.7
N472-226 -433	*Bvm*	N272-226⊗	8803	24.56	18.07	10	10	5.3	23.7	40.7	2.0	8.3	1.0
-434			6583	19.63	16.70	14	14	6.0	13.6	35.1	2.0	0.0	0.3
-435			6872	20.51	16.77	12	13	5.5	21.4	42.3	1.0	0.0	0.3
-436			8917	26.97	16.53	13	14	3.9	35.3	76.4	1.0	0.0	0.3

TEST 2605. PROGENY PERFORMANCE OF N412-#'s & N472-#'s UNDER SBCN AND RHIZOMANIA, SALINAS, CA, 2005 (cont.)

Variety	Resistance	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	DI %	%R (0-3) %	%R (0-4) %	Foliar Color Score	Root Rot %	PM Score
S_3 or S_n lines from N72 (cont.)													
Checks (cont.)													
N472-226-437	*Bvm*	N272-226⊗	6730	21.66	15.47	9	10	4.9	35.2	59.7	2.7	3.0	2.3
N472-227-441	*Bvm*	N272-227⊗	6509	20.32	15.67	17	16	4.8	30.0	52.6	1.3	0.0	1.3
-442			4904	15.27	15.90	18	18	5.2	21.4	51.9	1.7	0.0	2.3
-443			3967	11.99	16.60	14	13	5.1	11.9	45.2	2.0	7.1	2.0
Mean			7148.9	20.99	16.93	14.7	14.6	4.9	34.7	55.2	2.4	2.1	2.5
LSD (.05)			2344.9	6.94	1.51	3.8	4.9	1.2	27.6	27.5	1.2	9.0	1.4
C.V. (%)			20.4	20.54	5.52	15.9	20.7	15.9	49.5	31.0	31.5	271.5	33.5
F value			8.1**	6.90**	3.17**	7.0**	4.9**	9.0**	5.2**	7.2**	4.8**	1.2NS	17.0**

NOTES: Soil cores were taken early July for entries Beta 4430R and US H11 and averaged 615 and 0.0 eggs+larvae/100g soil, respectively. At harvest in mid-November, soil samples were made from Beta 4430R, N412-11, N412-13, N927-202, and US H11 and averaged 313, 150, 111, 165, and 408, respectively.

TEST 2705. PROGENY TEST OF P407/8-#'s (CP07) & P418-6-#'s (CP08) UNDER RHIZOMANIA/SBCN CONDITIONS FOR PMR, *Rz*, and NR, SALINAS, CA, 2005

96 entries x 3 reps., sequential
1-row plots, 11 ft. long

Planted: May 3, 2005
Harvested: November 17, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	Powdery Mildew Score
Checks									
$N412_{ISO}$	PMR-RZM N312	10742	31.34	17.10	21.50	79.5	145	0.3	0.0
$N472_{ISO}$	RZM-NR N372	10807	31.79	17.03	22.83	74.6	185	1.0	6.8
4931	3931aa x A (C931)	12742	36.71	17.30	22.83	75.9	176	2.3	0.0
US H11	susc. check	5084	15.99	15.83	20.47	77.5	185	3.7	0.0
P407/8	PMR-RZM-% P207/8 (CP07)	11219	32.79	17.13	21.83	78.5	179	0.3	0.0
P418-6	PMR-RZM P318-6 (CP08)	9399	27.15	17.27	22.67	76.1	176	0.3	0.0
Phoenix	9/12/03	10568	29.49	17.93	22.20	80.8	136	2.7	0.0
Roberta	2/25/04	7432	23.27	16.07	19.93	80.6	173	1.3	0.0
Beta 4430R	8/21/03	12951	36.53	17.73	21.93	80.9	182	1.3	0.0
Y475	RZM-ER-% Y275	11464	33.06	17.30	22.50	76.9	182	1.3	0.0
04-C37	Inc. 03-C37	6033	18.89	15.87	21.17	75.0	167	3.3	0.0
4927-202	Inc. 2927-4-202 (A,aa)	6489	20.06	16.03	20.40	78.5	185	1.0	0.0
Pair-crosses (PX) from P07/8 (CP07)									
P407/8-401	P307/8 PX	10904	31.47	17.23	23.00	74.9	139	0.7	1.9
-402		11892	33.38	17.77	22.77	78.1	170	0.0	0.0
-403		12462	34.13	18.27	23.13	79.0	179	1.7	0.0
-404		10452	30.07	17.40	23.20	75.0	170	0.7	0.0
-405		10669	29.56	17.97	23.50	76.4	179	0.3	1.8
-406		11228	31.12	18.10	23.60	76.7	179	0.0	3.3
-407		11793	32.12	18.27	23.07	79.2	142	0.7	0.0
-408		11685	29.91	19.37	23.57	82.2	194	0.0	3.5
-409		12478	33.86	18.43	24.30	75.9	176	0.0	0.0
-410		11722	30.24	19.37	24.13	80.2	164	0.0	3.5
-411		12550	34.13	18.40	23.17	79.4	185	0.0	0.0
-412		11349	30.91	18.17	23.03	78.8	188	0.0	0.0
P407/8-413	P307/8 PX	15506	43.57	17.80	22.43	79.3	158	0.0	0.0
-414		10877	30.55	17.63	22.30	79.1	170	0.3	3.5
-415		11388	30.94	18.40	23.30	79.0	188	1.0	0.0
-416		11202	30.64	18.27	23.97	76.2	173	0.3	5.3

TEST 2705. PROGENY TEST OF P407/8-#'s (CP07) & P418-6-#'s (CP08) UNDER RHIZOMANIA/SBCN CONDITIONS FOR PMR, Rz, and NR, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Soluble Solids	RJAP	Beets/ 100'	Root Rot	Powdery Mildew
		Lbs	Tons	%	%	%	No.	%	Score
Pair-crosses (PX) from P07/8 (CP07) (cont.)									
P407/8-417	P307/8 PX	11267	32.39	17.30	22.73	76.1	173	2.3	0.0
-418		9138	25.53	17.93	22.93	78.2	194	0.0	0.0
-419		8613	26.19	16.43	23.07	71.3	145	0.7	0.0
-420		10804	29.37	18.37	23.43	78.4	161	1.7	2.2
-421		12576	34.46	18.23	23.33	78.1	164	0.3	1.7
-422		10066	29.03	17.07	22.40	76.1	158	1.3	0.0
-423		10179	28.25	18.03	23.10	78.1	176	0.0	0.0
-424		12969	36.28	17.90	23.30	76.8	179	0.0	0.0
-425		10068	29.78	16.93	22.50	75.5	121	0.7	2.2
-426		6606	18.48	17.87	22.10	80.9	182	1.3	0.0
-427		12083	33.86	17.77	22.67	78.4	182	2.0	0.0
-428		9548	28.04	17.03	22.57	75.6	164	0.3	0.0
-429		7994	24.14	16.43	22.10	74.4	173	2.0	0.0
-430		13235	37.09	17.83	24.17	73.8	200	0.0	0.0
-431		9914	29.03	17.00	23.10	73.6	167	2.3	6.3
-432		12202	34.60	17.73	22.73	78.0	161	0.0	3.3
Checks									
N412(Sp)	N212-#(C), N312aa x A (CN12)	12134	34.40	17.63	22.57	78.2	173	1.0	0.0
N472(Sp)	N272-#(C), N372aa x A (CN72)	10272	28.92	17.77	22.57	78.7	161	1.7	0.0
P428	PMR-RZM P328 (CP04)	11250	32.52	17.23	22.00	78.3	188	0.7	0.0
P430	PMR-RZM P330 (CP06)	11950	33.43	17.87	22.90	78.1	167	0.7	0.0
Pair-crosses (PX) from P18-6 (CP08)									
P418-6-401	P318-6 PX	10508	29.83	17.67	23.63	74.8	161	0.0	0.0
-402		9701	29.13	16.50	21.70	76.0	155	3.0	0.0
-403		12186	37.25	16.33	21.27	76.9	161	1.0	0.0
-404		12371	36.93	16.77	22.50	74.5	139	1.7	0.0
-405		8521	25.81	16.53	21.20	78.0	148	1.7	0.0
-406		10245	30.45	16.83	21.67	77.7	148	2.3	0.0

TEST 2705. PROGENY TEST OF P407/8-#'s (CP07) & P418-6-#'s (CP08) UNDER RHIZOMANIA/SBCN CONDITIONS FOR PMR, *Rz*, and NR, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	Powdery Mildew Score
Pair-crosses (PX) from P18-6 (CP08) (cont.)									
P418-6-407	P318-6 PX	9880	28.22	17.57	22.83	77.0	155	0.0	2.1
-408		12077	36.28	16.63	21.37	77.9	173	0.3	0.0
-409		11078	31.12	17.80	23.00	77.4	194	0.0	0.0
-410		13579	37.87	18.00	22.63	79.5	136	0.0	0.0
-411		6411	18.78	17.00	21.83	78.0	155	1.0	2.6
-412		10489	29.56	17.80	22.83	78.0	173	3.7	5.3
-413		9343	27.41	17.03	22.23	76.7	167	3.3	0.0
-414		11972	33.33	18.00	22.87	78.7	173	0.3	0.0
-415		12148	34.27	17.70	22.57	78.4	191	0.0	0.0
-416		10100	27.72	18.30	24.03	76.2	142	0.0	0.0
-417		9695	29.46	16.47	21.80	75.5	161	1.3	0.0
-418		12452	35.21	17.70	22.70	78.0	179	1.3	0.0
-419		7283	20.33	17.93	22.77	78.8	142	2.0	0.0
-420		9738	28.19	17.33	22.60	76.7	197	1.3	11.8
-421		8950	26.02	17.23	23.60	73.1	182	3.0	3.3
-422		9481	27.15	17.60	22.23	79.2	176	1.7	0.0
-423		8583	25.13	17.03	22.20	76.7	170	0.0	4.5
-424		12282	36.01	17.03	21.87	77.9	161	0.3	0.0
-425		10421	30.45	17.13	22.20	77.2	142	1.3	0.0
-426		10556	29.56	17.83	22.93	77.8	191	0.0	0.0
P418-6-427	P318-6 PX	10302	29.32	17.60	23.47	75.0	179	0.0	2.9
-428		7751	21.39	18.13	23.97	75.7	142	1.7	0.0
-429		10091	28.49	17.70	23.03	76.9	148	0.0	2.2
-430		9898	29.77	16.60	21.10	78.7	115	0.0	3.0

TEST 2705. PROGENY TEST OF P407/8-#'s (CP07) & P418-6-#'s (CP08) UNDER RHIZOMANIA/SBCN CONDITIONS FOR PMR, *Rz*, and NR, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	Powdery Mildew Score
Pair-crosses (PX) from P18-6 (CP08) (cont.)									
P418-6-431	P318-6 PX	9362	27.40	17.03	22.37	76.2	145	2.0	3.3
-432		9193	25.82	17.80	22.70	78.4	173	0.0	3.5
-433		9517	27.63	17.30	23.03	75.1	170	1.3	2.0
-434		10452	30.49	17.13	22.67	75.6	155	1.0	0.0
-435		8719	26.18	16.67	22.13	75.4	167	0.0	2.1
-436		10552	29.56	17.83	22.57	79.0	182	1.0	0.0
-437		11326	31.88	17.77	22.80	77.9	152	0.0	9.8
-438		12399	34.97	17.70	22.67	78.1	182	0.7	1.8
-439		9285	26.41	17.60	21.90	80.4	139	2.3	2.1
-440		5947	18.20	16.33	22.13	73.8	130	0.7	0.0
-441		7384	22.99	16.10	22.37	72.1	91	1.0	0.0
-442		7222	22.14	16.43	22.00	74.6	115	0.3	4.8
-443		6646	20.97	15.80	22.20	71.0	109	0.7	0.0
-444		10312	29.78	17.27	22.57	76.5	121	1.7	2.6
-445		10460	30.45	17.17	22.23	77.3	139	1.0	4.4
-446		7523	20.10	18.70	23.80	78.6	127	4.3	2.4
-447		8552	25.80	16.57	21.87	75.8	136	0.7	0.0
-448		10492	30.45	17.23	22.33	77.2	139	0.3	0.0
Mean		10306.2	29.49	17.42	22.58	77.2	162.8	1.3	1.0
LSD (.05)		2957.9	7.98	1.19	1.14	4.7	39.3	6.6	0.9
C.V. (%)		17.8	16.79	4.23	3.13	3.8	15.0	322.8	55.4
F value		3.3**	3.12**	2.89**	3.93**	1.6**	2.4**	0.9NS	10.4**

NOTES: Soil cores were taken early July for US H11 and Beta 4430R and averaged 27 and 140 eggs+larvae/100g soil, respectively. At harvest in mid-November, counts for US H11, Beta 4430R, 4927-202, N412Sp, N472Sp, and P428 were 1381, 663, 215, 322, 415, & 532, respectively.

TEST 2805. PROGENY TEST OF S_2's AND FS's FROM C931, C37, 747 x R36 (C79-8) UNDER RZM/SBCN, SALINAS, CA, 2005

64 entries x 3 reps., sequential
1-row plots, 11 ft. long

Planted: May 3, 2005
Harvested: November 18, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	Powdery Mildew Score
Checks									
4931	3931aa x A, (C931)	9950	28.76	17.33	21.50	80.5	179	1.9	1.0
R336	RZM-ER-% R136, (C79-8)	7811	23.11	16.90	21.90	77.2	197	0.0	1.7
04-C37	Inc. 03-C37	4195	12.82	16.30	21.10	77.3	194	0.0	4.0
4747	Inc. 0747 (A,aa)	5485	17.12	15.80	20.50	77.1	167	0.0	3.0
S_2's of C931 x R36									
4235-1 -401	2235-1-1⊗	3700	11.09	16.97	20.27	84.0	164	1.8	1.7
4235-1 -407	2235-1-2⊗	7591	21.11	18.10	21.57	84.0	164	0.0	0.7
4235-3 -411	2235-1-3⊗	8481	27.82	15.23	22.23	68.5	155	0.0	2.3
4235-4 -418	2235-1-4⊗	8752	25.00	17.50	23.27	75.2	185	0.0	1.0
4235-5 -423	2235-1-5⊗	8364	24.46	17.07	23.33	73.1	136	0.0	2.0
4235-12 -427	2235-2-12⊗	4522	13.33	17.00	23.10	73.6	158	0.0	5.7
4235-23 -432	2235-3-23⊗	3479	10.05	17.27	20.97	82.3	185	0.0	0.7
4235-31 -439	2235-4-31⊗	6413	19.49	16.37	22.53	72.6	124	0.0	3.3
Full-sibs of C37 x R36 (FS of FS's)									
4236-21 -401	2236-3-21PX	6190	18.80	16.53	21.33	77.5	148	1.9	3.0
-403		7227	19.95	18.20	21.70	83.9	158	3.4	2.3
4236-22 -407		5678	15.97	17.87	23.07	77.5	170	7.3	2.7
-408		6833	21.18	16.27	21.43	75.9	164	0.0	4.0
4236-41 -413	2236-5-41PX	4922	14.24	17.47	20.93	83.4	182	1.5	2.3
-414		6306	18.01	17.73	21.10	84.2	176	1.7	2.3
4236-42 -418	2236-5-42PX	4340	12.80	16.97	21.73	78.1	136	0.0	4.0
-419		4233	13.40	15.77	21.00	75.1	148	0.0	4.3
04-C37	Inc. 03-C37	5157	15.05	17.17	22.00	78.1	176	0.0	5.0

TEST 2805. PROGENY TEST OF S_2's AND FS's FROM C931, C37, 747 x R36 (C79-8) UNDER RZM/SBCN, SALINAS, CA, 2005 (cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	Powdery Mildew Score
S_2's of popn-747 x R36									
4237-1 -401	2237-1-1⊗	3735	11.29	16.50	21.67	76.3	170	0.0	2.7
-402		5593	16.66	16.80	21.57	77.9	173	1.7	2.7
4237-2 -407	2237-1-2⊗	6469	17.74	18.13	22.80	79.5	167	0.0	2.0
4237-2 -408	2237-1-2⊗	7185	17.50	20.77	24.47	84.8	161	0.0	0.3
Checks									
R336	RZM-ER-% R136 (C79-8)	11604	29.56	19.73	21.50	91.9	206	0.0	3.0
4747	Inc. 0747 (A,aa)	6642	17.47	18.73	20.80	89.7	167	0.0	4.7
S_2 of popn-747 x R36 (cont.)									
4237-3 -412	2237-1-3⊗	5019	14.22	17.90	21.17	84.3	200	0.0	1.0
-413		5057	13.98	18.10	23.60	76.7	197	0.0	1.3
4237-4 -416	2237-1-4⊗	5526	13.98	19.70	24.33	81.0	191	0.0	3.0
-417		5019	15.19	16.60	22.90	72.4	170	0.0	4.3
4237-5 -421	2237-1-5⊗	4475	11.34	19.70	22.90	86.0	173	0.0	2.3
-422		6708	16.66	20.13	24.83	81.1	170	0.0	1.0
4237-6 -427	2237-1-6⊗	5390	15.56	17.17	22.20	77.4	167	0.0	1.3
-428		5478	16.31	16.80	21.97	76.5	136	0.0	2.0
4237-13 -433	2237-2-13⊗	3777	11.97	15.90	20.90	76.2	139	0.0	1.3
4237-13 -434	2237-2-13⊗	4898	15.91	15.53	20.10	77.2	115	0.0	1.0
-435		3163	11.89	13.23	20.93	63.1	139	0.0	1.0
-436		2801	8.76	16.00	20.70	77.2	91	3.3	1.7
-437		7789	22.99	16.83	22.03	76.3	118	0.0	1.3
4237-13 -438		5022	15.09	16.70	20.30	82.7	158	1.6	2.0
4237-14 -440	2237-2-14⊗	2935	8.99	16.03	20.93	76.4	173	0.0	4.3
-441		2693	7.79	17.10	20.03	85.2	206	0.0	1.0
4237-14 -442	2237-2-14⊗	3543	11.56	15.30	21.10	72.5	155	0.0	3.7

TEST 2805. PROGENY TEST OF S_2's AND FS's FROM C931, C37, 747 x R36 (C79-8) UNDER RZM/SBCN, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	Powdery Mildew Score
S_2 of popn-747 x R36 (cont.)									
4237-22 -445	2237-3-22⊗	7676	22.33	17.10	22.07	77.5	136	0.0	4.3
-446		8118	24.99	16.17	21.00	77.0	52	0.0	4.3
4237-23 -449	2237-3-23⊗	6312	20.96	15.07	19.27	78.3	182	1.6	3.0
-450		9237	29.66	15.60	20.03	77.9	152	0.0	3.0
4237-23 -451	2237-3-23⊗	5567	17.74	15.67	20.53	76.3	152	0.0	1.3
4237-31 -454	2237-4-31⊗	5289	18.25	14.67	18.93	77.4	161	0.0	1.7
-455		6061	19.49	15.57	20.00	77.9	167	0.0	2.0
-456		6999	21.73	16.13	20.37	79.2	152	0.0	2.3
4237-31 -457		8081	23.98	16.93	20.90	81.0	127	0.0	2.0
4237-32 -461	2237-4-32⊗	5326	16.70	15.77	20.80	75.8	164	0.0	6.0
-462		5789	17.20	16.67	21.67	76.9	148	0.0	3.0
-463		6580	20.99	15.63	20.30	77.0	145	0.0	2.7
4237-32 -464		11163	30.53	18.27	22.03	82.7	179	0.0	2.0
4237-41 -468	2237-5-41⊗	4588	13.89	15.83	20.40	77.4	176	0.0	4.3
-469		4357	13.79	15.80	20.70	76.4	173	1.9	3.7
4237-41 -470	2237-5-41⊗	5536	17.23	16.27	20.47	79.4	139	0.0	4.7
4237-42 -474	2237-5-42⊗	9121	27.76	16.43	21.53	76.3	164	2.1	3.7
-475		5831	19.27	15.13	19.47	77.7	136	4.3	3.7
-476		6530	20.52	15.90	21.87	72.7	167	3.5	1.0
-477		3728	12.09	15.37	21.37	71.9	148	0.0	2.7
Mean		5969.4	17.74	16.80	21.47	78.3	159.7	0.6	2.6
LSD (.05)		2023.6	5.57	2.15	1.41	8.5	39.1	3.0	1.4
C.V. (%)		21.0	19.44	7.91	4.07	6.8	15.1	305.3	33.3
F value		7.3**	7.64**	3.17**	5.78**	2.3**	3.5**	1.5*	7.1**

NOTES: Soil cores were taken early July for 4747 and averaged 701 egg+larvae/100g soil. At harvest in mid-November, counts for R336, 4747, R336, 4747 were 382, 591, 571, and 1802, respectively.

TEST 2905. PROGENY TEST S_4's FROM POPN-926 FOR DIVERGENT SELECTION FOR REACTION TO RZM & SBCN, SALINAS, CA, 2005

32 entries x 3 reps., sequential
1-row plots, 11 ft. long

Planted: May 3, 2005
Harvested: November 15, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	DI %	%R (0-3) %	%R (0-4) %	Foliar Color Score	Root Rot %	PM Score
Checks												
8926 (Iso)	RZM 7926(A,aa),(Rz1 x R22*gp*)	8286	24.59	16.93	18	18	3.4	53.6	90.4	3.0	7.4	2.0
0926	RZM-% 8926(Sp),(7931 x 7926)	9006	25.26	17.77	20	21	3.5	58.1	78.8	2.0	1.6	2.3
4931	3931aa x A, (C931)	7912	22.04	17.93	19	20	3.5	60.3	85.0	3.0	5.0	2.0
US H11		5093	15.65	16.23	21	18	5.8	19.2	35.0	4.0	2.9	4.0
R336	RZM-ER-% R136	8091	24.32	16.63	19	21	3.2	64.5	91.9	2.0	0.0	3.7
04-C37	Inc. 03-C37	3465	10.62	16.37	19	19	6.0	8.8	25.3	3.7	1.9	5.0
4926-11-1-3	Inc. 2926-11-1-3	7092	21.84	16.50	19	19	3.4	63.5	91.8	2.0	0.0	1.7
4926-11-3-22	Inc. 2926-11-3-22	7434	20.49	18.07	20	18	4.5	27.5	54.3	1.7	0.0	2.0
4926-11-7-61	Inc. 2926-11-7-61	5891	15.75	18.67	20	19	5.3	6.7	30.3	2.0	11.1	1.0
4926-11-10-91	Inc. 2926-11-10-91	7400	21.22	17.43	19	18	4.9	11.9	36.4	1.7	1.4	1.3
S_4 progenies from 8926 (2926-11-#-#⊗ = 1926-11-#⊗ = 9926-11⊗ = 8926												
4926-1 -401	2926-11-1-1⊗	7261	20.55	17.70	11	11	4.1	32.6	62.5	2.7	5.6	1.0
4926-2 -406	2926-11-1-2⊗	7131	21.10	16.93	4	4	5.1	0.0	38.1	2.3	0.0	1.0
4926-3 -412	2926-11-1-3⊗	7403	21.63	17.17	12	12	3.9	26.8	80.7	2.0	0.0	1.7
4926-4 -416	2926-11-1-4⊗	7842	23.02	17.03	14	14	4.1	39.4	73.9	2.7	0.0	2.7
4926-21 -423	2926-11-3-21⊗	5209	15.34	17.20	10	12	6.7	4.2	12.5	2.0	0.0	1.7
4926-22 -431	2926-11-3-22⊗	6233	17.02	18.33	12	11	5.3	10.7	24.4	1.7	12.5	1.0
4926-23 -434	2926-11-3-23⊗	5755	17.20	16.87	17	17	5.2	19.6	41.2	1.7	0.0	3.7
4926-24 -439	2926-11-3-24⊗	6218	18.81	16.53	15	16	4.3	23.1	62.9	1.3	0.0	4.0
4926-31 -446	2926-11-4-31⊗	5160	15.68	16.47	12	12	7.5	0.0	0.0	1.3	0.0	1.0
4926-32 -454	2926-11-4-32⊗	6104	20.71	14.73	10	10	5.5	13.1	35.7	2.0	0.0	1.7

TEST 2905. PROGENY TEST S_4's FROM POPN-926 FOR DIVERGENT SELECTION FOR REACTION TO RZM & SBCN, SALINAS, CA, 2005
(cont.)

Variety		Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Stand Count	Harv Count	DI	%R (0-3)	%R (0-4)	Foliar Color	Root Rot	PM
			Lbs	Tons	%	No.	No.	%	%	%	Score	%	Score
S_4 progenies from 8926 (2926-11-#-#⊗ = 1926-11-#⊗ = 9926-11⊗ = 8926 (cont.)													
4926-33	-460	2926-11-4-33⊗	6250	20.96	14.87	14	12	4.6	15.6	47.7	2.0	4.2	1.0
4926-34	-468	2926-11-4-34⊗	5735	17.31	16.57	9	9	4.7	15.1	54.0	1.3	0.0	2.0
4926-41	-476	2926-11-5-41⊗	6295	19.08	16.53	16	17	5.7	6.4	30.6	1.0	0.0	2.0
4926-43	-484	2926-11-5-42⊗	5157	16.29	15.77	15	15	5.9	6.4	13.1	2.3	0.0	3.3
4926-51	-492	2926-11-6-51⊗	7640	22.37	17.10	15	15	4.4	24.4	61.7	1.0	0.0	1.7
4926-61	-498	Inc. 2926-11-7-61⊗	8007	20.43	19.60	21	22	4.0	37.2	69.2	1.7	0.0	1.7
4926-71	-504	2926-11-8-71⊗	7319	22.98	15.93	13	14	3.7	53.1	80.4	2.0	0.0	1.7
4926-72	-511	2926-11-8-72⊗	7037	21.53	16.30	11	11	3.4	58.3	91.7	1.7	0.0	2.0
S_4 progenies from 8926 (2926-11-#-#⊗ = 1926-11-#⊗ = 9926-11⊗ = 8926													
4926-91	-517	2926-11-10-91⊗	8026	20.60	19.47	14	14	4.9	17.0	55.6	2.0	0.0	0.3
4926-92	-522	2926-11-10-92⊗	6864	19.05	18.10	13	13	5.7	2.2	24.4	2.7	0.0	0.3
4926-101	-528	2926-11-11-101⊗	5652	16.89	16.73	14	14	4.3	32.7	66.2	2.7	0.0	0.0
4926-102	-535	2926-11-11-102⊗	6264	19.26	16.20	13	10	6.1	2.6	10.3	3.0	9.5	0.3
Mean			6694.7	19.68	17.02	15.0	14.9	4.8	25.5	51.8	2.1	2.0	1.9
LSD (.05)			1663.2	4.85	1.34	3.6	5.8	1.2	26.8	36.4	1.2	11.3	1.2
C.V. (%)			15.2	15.12	4.82	14.8	23.9	15.9	64.4	43.1	34.6	352.4	39.7
F value			4.2**	3.52**	5.44**	10.5**	3.9**	5.9**	4.8**	4.5**	2.7**	0.8NS	7.5**

NOTES: Soil cores were taken early July for 4931 and USH11 and averaged 899 and 255 eggs+larvae/100g soil, respectively. At harvest in mid-November, counts for 4931, USH11, R336, 04-C37, 4926-11-3-22, 4926-21-423, 4926-22-431, 4926-23-476, and 4926-24-439 were 430, 905, 0.0, 469, 75, 50, 0.0, 739, and 152, respectively.

TEST 5105. EVALUATION OF LINES & HYBRIDS UNDER RHIZOMANIA & CERCOSPORA LEAF SPOT, SALINAS, CA, 2005

64 entries x 6 reps., sequential
1-row plots, 11 ft. long

Planted: May 4, 2005
Harvested: November 21, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/ 100' No.	Foliar Color Score	PM Score	Cercospora Leaf Spot 11/04	Cercospora Leaf Spot 11/09	Cercospora Leaf Spot 11/21	Cercospora Leaf Spot Mean
Checks												
Beta 4430R	8/21/03	13742	39.51	17.30	81.4	200	1.7	0.5	5.8	4.8	6.3	5.7
Roberta	2/25/04	4985	16.82	14.92	79.0	156	2.2	1.0	5.3	4.0	5.5	4.9
EL-SP7322-0	Inc. SP7322-0, 4/05	4612	15.16	15.23	78.5	165	4.5	4.2	2.2	2.0	3.2	2.4
CR411	RZM CR311aa x A	12322	34.99	17.62	80.9	171	1.5	2.3	2.0	1.7	1.7	1.8
Multigerm lines and populations												
Y491	Inc. Y391	11986	31.98	18.80	80.3	126	1.3	0.7	2.2	1.5	1.8	1.8
Y492	RZM-ER-% Y292	13181	35.11	18.75	81.1	195	1.3	1.2	2.8	2.0	2.0	2.3
Y475	RZM-ER-% Y275	11624	31.45	18.48	80.8	198	1.3	1.5	2.5	1.7	2.0	2.1
R421	RZM-ER-% R221	13056	36.93	17.70	81.0	177	1.0	1.2	2.3	1.5	1.5	1.8
Z210	Inc.Z010-Z017 Polish%S(C)	5740	15.82	18.05	80.9	144	4.0	2.2	6.0	5.3	5.8	5.7
4943	RZM 3943aa x A	12461	33.73	18.47	79.9	161	2.2	1.3	3.3	2.3	3.2	2.9
Z425	RZM Z325aa x A	13002	35.79	18.12	79.1	167	1.5	1.7	3.3	2.2	3.0	2.8
4931	RZM 3931aa x A	11566	31.66	18.23	80.4	174	2.0	1.0	3.2	3.0	3.8	3.3
4941	RZM 3941aa x A	10286	28.76	17.85	79.4	158	1.8	1.0	3.0	2.5	2.3	2.6
CR411	RZM CR311aa x A	12515	35.76	17.48	80.7	170	2.0	2.2	2.2	1.7	2.0	1.9
03-SP22-0	Inc. 01-SP22-0	4466	14.11	15.80	80.5	189	5.0	3.8	2.0	2.5	2.0	2.2
2933	RZM-% 9933 (A,aa)	11662	33.06	17.68	80.1	189	1.7	1.5	2.0	1.5	2.0	1.8
04-FC1028	RZM-% FC20021028	9738	27.41	17.72	80.3	176	2.0	0.5	1.7	1.3	1.5	1.5
04-FC1037	RZM-% FC20021037	11334	31.11	18.20	79.9	179	1.7	2.2	2.2	1.7	1.5	1.8
04-FC1038	RZM-% FC20021038	11777	32.51	18.12	78.6	180	1.3	2.8	1.3	1.2	1.0	1.2
N412 Sp	N212-#(C), N312aa x A	10533	30.76	17.12	76.5	177	2.0	0.8	2.0	1.5	1.7	1.7
N472 Sp	N272-#(C), N372aa x A	13521	37.47	18.03	80.2	167	1.8	1.2	2.0	1.5	1.3	1.6

TEST 5105. EVALUATION OF LINES & HYBRIDS UNDER RHIZOMANIA & CERCOSPORA LEAF SPOT, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/ 100' No.	Foliar Color Score	PM Score	Cercospora Leaf Spot 11/04	Cercospora Leaf Spot 11/09	Cercospora Leaf Spot 11/21	Cercospora Leaf Spot Mean
Multigerm progeny lines												
4933-14 Sp	2933-14aa x A	10048	25.92	19.35	82.9	164	1.0	0.8	1.0	1.2	1.3	1.2
CR310-14-2	RZM CR110-14-2 (A,aa)	7165	21.18	16.90	78.9	150	1.2	2.3	0.5	1.0	1.0	0.8
CR410-231	Inc. CR210-14-2-231	6837	20.29	16.85	77.2	167	1.2	1.3	0.3	1.0	1.0	0.8
CR009-1	RZM CR909-1aa x A, (CR09-1)	9550	27.01	17.72	77.5	133	1.3	2.0	2.2	2.0	3.2	2.4
CR410-203	Inc. CR210-5-203	8464	23.07	18.33	76.8	159	2.7	3.2	1.5	1.3	2.0	1.6
CR412-211	Inc. CR212-5-211	10080	28.52	17.70	79.1	183	1.2	0.8	1.7	1.5	1.5	1.6
CR412-5	Inc. CR212-5-#(C)	9464	26.61	17.82	79.5	176	1.2	2.2	1.0	1.0	1.2	1.1
CR311-6	Inc. CR111-6 (A,aa)	10096	28.10	17.93	78.8	191	2.3	1.7	1.0	1.3	1.2	1.2
CR311-88	Inc. CR111-88 (A,aa)	12064	34.40	17.50	80.6	186	1.8	3.7	2.0	1.3	2.2	1.8
4933-14 Iso	RZM 2933-14 (A,aa)	7873	20.92	18.77	82.0	170	1.0	1.0	1.5	1.0	1.0	1.2
4951-210	Inc. 2951-210 (A,aa)	10205	27.95	18.28	78.6	173	1.5	1.3	0.3	0.8	1.2	0.8
03-FC1030-15	Inc. 01-FC1030-15	8461	22.29	18.98	81.1	155	2.5	1.5	2.8	2.2	3.7	2.9
03-FC1030-16	Inc. 01-FC1030-16	9457	26.88	17.60	80.9	180	3.2	4.0	2.7	2.8	4.0	3.2
Monogerm lines & populations												
03-FC1014-22	Inc. 01-FC1014-22 (A,aa)	7776	21.03	18.28	79.6	164	1.7	2.0	2.5	2.2	2.0	2.2
03-FC123-31	Inc. 01-FC123-31 (A,aa)	7398	20.89	17.65	79.7	170	2.3	3.3	3.0	3.2	2.5	2.9
03-FC124	RZM 02-FC124mmaa x A	10068	27.56	18.23	78.6	141	1.5	1.8	2.2	1.7	2.3	2.1
03-FC1015	RZM 02-FC1015mmaa x A	9025	25.44	17.75	80.4	162	1.5	1.3	3.5	2.2	2.0	2.6
4842m	RZM-% 2842 (A,aa)	8937	25.36	17.63	78.6	188	1.7	2.3	3.0	2.0	3.0	2.7
4843m	RZM,T-O 3843-#(C)mmaa x A	8528	23.58	18.07	80.7	150	1.3	1.2	4.3	3.2	4.3	3.9
Hybrids												
HM-E17	CR ck, 4/05 (Syngenta)	5878	17.22	16.95	79.4	162	3.8	3.7	1.8	2.0	2.8	2.2
Monohikari	CR ck, 1/21/03	7463	22.39	16.27	81.2	189	3.3	3.7	3.3	2.8	3.2	3.1

TEST 5105. EVALUATION OF LINES & HYBRIDS UNDER RHIZOMANIA & CERCOSPORA LEAF SPOT, SALINAS, CA, 2005 (cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/ 100' No.	Foliar Color Score	PM Score	Cercospora Leaf Spot 11/04	Cercospora Leaf Spot 11/09	Cercospora Leaf Spot 11/21	Cercospora Leaf Spot Mean
Hybrids (cont.)												
ACH555	CLSR ck, lot 8107307, 3/8/02	7305	20.43	17.85	78.6	201	4.8	2.5	1.3	1.3	1.8	1.5
Beta 4430R	8/21/03	13528	37.09	18.23	83.6	183	2.2	0.5	5.2	4.7	6.3	5.4
CR411H50	C790-15CMS x CR311	11329	32.12	17.57	79.6	189	1.2	1.3	3.2	2.2	2.7	2.7
4933-14H50	x 2933-14	12579	33.46	18.78	80.9	176	1.2	1.0	2.8	1.7	1.3	1.9
CR311-6H50	x CR111-6	10053	28.35	17.72	79.7	197	2.3	2.5	3.2	2.5	3.5	3.1
CR311-88H50	x CR111-88	11863	33.33	17.83	80.5	211	1.5	1.5	3.2	2.2	3.5	2.9
CR311-41H50	x CR111-41	11519	32.92	17.47	80.6	208	1.0	1.3	2.8	2.2	2.0	2.3
3933-118H50	x 1933-118	13107	36.15	18.07	82.1	188	1.0	1.5	2.5	1.8	2.3	2.2
CR410-231H50	x CR210-14-2-231	12303	35.31	17.50	80.5	188	1.5	2.7	2.5	1.5	1.7	1.9
CR412-211H50	x CR212-5-211	12831	34.94	18.40	81.8	220	1.0	0.8	2.8	2.3	3.3	2.8
CR412-5H50	x Inc. CR212-5-#(C)	12026	32.92	18.27	82.6	188	1.3	1.5	2.0	1.3	1.5	1.6
CR410-203H50	x CR210-5-203	12041	33.35	17.95	78.6	180	1.7	2.2	2.3	2.0	2.5	2.3
03-FC1030-15H50	x 01-FC1030-15	9305	26.43	17.57	77.1	185	1.8	1.3	3.8	3.3	3.7	3.6
03-FC1030-16H50	x 01-FC1030-16	9966	28.70	17.17	81.3	177	3.0	1.2	3.7	3.2	4.8	3.9
04-FC1028H5	C833-5H0 x RZM-% FC20021028	11418	32.01	17.82	79.8	153	1.0	1.2	2.5	1.7	2.0	2.1
04-FC1037H5	x RZM-% FC20021037	11416	30.89	18.47	79.4	159	2.0	1.3	3.0	2.3	2.2	2.5
04-FC1038H5	C833-5HO x RZM-% FC20021038	12801	35.05	18.27	80.7	139	1.3	3.2	2.2	1.8	1.3	1.8
4933-14H5	x 2933-14	11778	30.87	19.05	82.6	165	1.5	1.2	2.5	1.8	1.8	2.1

TEST 5105. EVALUATION OF LINES & HYBRIDS UNDER RHIZOMANIA & CERCOSPORA LEAF SPOT, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/ 100' No.	Foliar Color Score	PM Score	Cercospora Leaf Spot 11/04	11/09	11/21	Mean
Hybrids (cont.)												
CR411H5	C833-5HO x CR311	12337	33.73	18.28	80.4	171	1.3	2.0	2.3	1.7	1.7	1.9
4951-210H50	C790-15CMS x 2951-210	13229	36.89	17.90	78.7	195	1.3	1.0	1.7	1.5	1.5	1.6
HM-E17	CR check, 4/05 (Michigan Sugar)	5636	16.50	16.97	80.5	177	4.7	4.7	2.2	2.5	4.3	3.0
Angelina	2/25/04	12943	34.54	18.63	81.2	191	1.3	4.0	3.2	2.7	5.0	3.6
Mean		10316.5	28.79	17.81	80.04	174.6	1.9	1.9	2.5	2.1	2.5	2.4
LSD (.05)		1925.5	4.95	0.93	3.35	30.1	0.8	0.9	0.9	0.7	1.2	0.8
C.V. (%)		16.4	15.14	4.58	3.68	15.2	36.9	42.3	29.7	30.9	42.6	28.2
F value		12.7**	13.17**	5.79**	1.45*	3.0**	11.6**	10.2**	13.8**	12.1**	9.1**	15.7**

NOTES: Tests 5105 thru 5305 were inoculated twice with *Cercospora beticola* on July 26 and September 6, 2005. Leaf spot development was slow but fairly uniform and developed to a moderate level. Over 3 weeks prior to harvest, the test was scored three times for leaf spot by RTL, JO, and DP. The mean of these scores is given. Because disease development occurred late, leaf spot probably had relatively little impact on yield.

The development and expression of rhizomania appeared to be nearly ideal in test 5105. Rhizomania appeared to be uniform and known susceptible entries appeared uniformly susceptible. Because the test was machine harvested, root scores were not taken.

Foliar scores were taken just prior to harvest. Ideally, scoring would have been better in September or early October. By mid November, the canopy color had evened out to some extent. Scores were made from 1 to 5 where 5 = 100% yellowing associated with rhizomania.

TEST 5305. CERCOSPORA EVALUATION OF S_1 PROGENIES FROM FC124 & FC1015 UNDER RHIZOMANIA, SALINAS, CA, 2005

63 entries* x 3 reps., sequential
1-row plots, 11 ft. long

Planted: May 4, 2005
Harvested: November 22, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/ 100' No.	Foliar Color Score	PM Score	Cercospora Leaf Spot 11/01	Cercospora Leaf Spot 11/08	Cercospora Leaf Spot 11/21	Cercospora Leaf Spot Mean
Checks												
EL·SP73322-O	Inc. SP7322-0	5026	18.54	13.00	79.7	182	4.3	2.3	4.7	3.3	4.3	4.1
Roberta	2/25/04	5100	17.87	14.47	88.6	209	2.0	1.3	4.3	4.0	3.7	4.0
Beta 4430R	8/21/03	13931	43.48	16.07	83.8	215	1.3	0.0	7.0	5.7	6.7	6.4
HM-E17	4/05, Syngenta	6497	20.29	15.87	80.5	182	3.0	1.3	4.0	3.0	4.7	3.9
CR410-231	Inc. CR210-14-2-231	7643	22.30	17.10	78.6	182	1.0	0.0	2.0	1.0	1.0	1.3
CR412-211	Inc. CR212-5-211	7998	24.72	16.23	76.4	191	1.3	0.0	3.3	2.3	1.7	2.4
CR412-5	Inc. CR212-5-211,212,216,218	9060	27.11	16.77	78.1	218	1.3	1.0	2.3	1.0	1.0	1.4
CR410-203	Inc. CR210-5-203	7958	22.84	17.37	76.6	161	2.0	1.0	3.0	1.7	3.0	2.6
S_1 progenies from mm-popn-FC1015												
04-FC1015 -401	RZM 03-FC1015mm⊗	8673	24.75	17.40	80.9	203	1.3	1.0	4.3	2.0	2.3	2.9
-402		8317	24.19	17.07	81.5	203	1.7	0.7	5.3	3.0	2.3	3.6
-403		10409	27.68	18.83	81.8	167	1.0	0.7	3.7	2.3	1.7	2.6
-404		8473	23.48	17.97	81.5	182	1.3	0.7	4.3	3.3	3.0	3.6
-405		8196	23.65	17.17	77.7	167	2.3	1.0	5.0	2.7	3.3	3.7
-406		6431	19.05	16.87	78.2	212	1.7	1.0	7.0	4.3	6.7	6.0
-407		9226	26.63	17.40	81.2	188	1.3	0.7	4.7	3.0	4.0	3.9
-408		7463	22.15	16.73	79.4	152	2.0	1.0	6.3	4.3	5.7	5.4
-409		7395	21.87	16.87	79.3	179	2.3	1.0	5.3	3.3	3.7	4.1
-410		7365	22.57	16.37	74.4	185	1.7	1.0	4.7	2.7	2.0	3.1
-411		9096	26.28	17.43	81.9	161	1.7	0.3	4.7	2.7	3.3	3.6
-412		8355	23.97	17.40	82.9	164	2.0	0.3	5.0	4.0	4.7	4.6
-413		8992	26.90	16.60	81.2	121	1.0	1.0	4.3	2.7	2.7	3.2
-414		7514	22.20	16.77	78.4	158	1.3	1.0	5.3	3.0	4.7	4.3

TEST 5305. CERCOSPORA EVALUATION OF S_1 PROGENIES FROM FC124 & FC1015 UNDER RHIZOMANIA, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/ 100' No.	Foliar Color Score	PM Score	Cercospora Leaf Spot 11/01	Cercospora Leaf Spot 11/08	Cercospora Leaf Spot 11/21	Cercospora Leaf Spot Mean
S_1 progenies from mm-popn-FC1015 (cont.)												
04-FC1015 -415	RZM 03-FC1015mm⊗	7571	23.11	16.40	77.7	91	2.0	1.0	4.3	2.0	1.0	2.4
-416		11024	30.88	17.83	84.4	109	1.3	1.0	4.0	3.0	2.0	3.0
-417		9248	25.26	18.23	82.7	118	1.0	1.3	4.0	3.0	3.3	3.4
-418		2897	12.68	11.47	80.9	112	4.0	2.0	7.7	5.0	6.3	6.3
-419		6173	23.70	13.27	66.0	152	2.0	1.0	6.3	4.0	3.0	4.4
-420		10121	27.05	18.63	83.6	112	1.0	1.3	3.3	2.0	2.3	2.6
-421		8749	25.53	17.13	76.7	164	1.3	2.0	3.3	3.0	4.0	3.4
-422		13818	44.59	15.50	80.3	18	1.7	1.0	3.7	1.7	1.0	2.0
-423		7782	24.63	15.83	78.1	124	2.7	1.0	5.0	3.7	5.0	4.6
-424		7878	25.85	15.10	76.0	94	1.7	1.0	4.0	1.7	1.0	2.2
-425		9301	25.02	18.53	80.8	164	1.3	1.0	3.3	2.3	2.3	2.7
-426		8430	23.71	17.67	77.2	161	1.7	1.3	5.0	3.3	2.3	3.6
-427		11110	32.80	16.93	81.2	82	1.3	0.3	3.0	1.7	1.0	1.9
-428		3953	13.68	14.47	82.9	97	2.3	1.0	4.3	3.0	3.3	3.6
S_1 progenies from mm-popn-FC124												
04-FC124 -401	RZM 03-FC124mm⊗	11732	32.53	18.00	82.7	145	1.3	1.0	4.7	3.3	4.7	4.2
-402		7677	23.80	16.07	76.4	185	2.7	1.3	5.7	3.7	3.7	4.3
-403		8835	29.56	15.03	77.5	194	1.7	0.3	5.0	3.3	4.0	4.1
-404		7250	23.03	15.73	79.4	185	1.0	1.3	4.7	3.0	4.0	3.9
-405		9886	33.10	14.90	76.9	142	1.3	1.3	4.3	3.0	3.0	3.4
-406		6560	21.01	15.50	75.8	136	1.3	1.0	5.7	4.0	4.3	4.7
-407		10633	32.62	16.30	79.7	155	1.3	1.0	4.0	3.3	4.7	4.0
-408		7901	22.87	17.13	80.1	130	2.7	1.0	2.3	3.0	3.3	2.9
-409		8030	23.92	16.20	80.7	170	1.7	1.7	6.3	4.3	5.3	5.3
-410		7125	22.68	15.67	78.2	158	1.7	0.7	7.0	5.0	5.7	5.9
-411		7054	22.14	15.97	77.1	191	2.0	1.3	5.7	4.7	6.3	5.6
-412		8271	24.70	16.67	79.0	173	1.7	0.7	5.0	4.0	5.7	4.9

TEST 5305. CERCOSPORA EVALUATION OF S_1 PROGENIES FROM FC124 & FC1015 UNDER RHIZOMANIA, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/ 100' No.	Foliar Color Score	PM Score	Cercospora Leaf Spot 11/01	Cercospora Leaf Spot 11/08	Cercospora Leaf Spot 11/21	Cercospora Leaf Spot Mean
S_1 progenies from mm-popn-FC124 (cont.)												
04-FC124 -413	RZM 03-FC124mm⊗	8316	24.45	17.00	77.8	176	1.3	1.0	2.3	1.7	1.0	1.7
-414		8020	23.46	17.17	78.4	170	1.7	1.3	4.0	2.7	3.0	3.2
-415		6119	18.81	16.27	77.7	148	3.0	1.0	5.3	3.7	5.7	4.9
-416		6261	20.45	15.33	78.9	176	1.7	0.7	6.3	4.0	4.7	5.0
-417		10150	30.66	16.53	77.8	152	1.0	1.0	4.3	3.0	5.3	4.2
-418	no plants											
-419		8679	25.42	17.07	78.5	161	2.0	2.7	3.7	2.7	3.0	3.1
-420		6470	22.89	13.97	74.2	121	2.3	1.3	7.0	5.3	6.0	6.1
-421		8524	25.03	16.97	82.5	100	1.7	1.3	6.0	4.7	5.7	5.4
-422		8181	25.60	15.90	80.2	106	1.3	1.0	4.7	3.3	3.0	3.7
-423		7269	23.68	15.43	75.8	152	1.7	1.3	5.0	3.3	4.3	4.2
-424		9514	28.04	16.97	81.7	109	1.0	2.0	4.3	3.0	3.7	3.7
-425		9370	24.94	18.83	80.9	142	1.3	0.3	3.7	2.3	2.7	2.9
-426		7740	23.94	16.17	78.8	127	1.3	1.0	5.7	3.7	4.3	4.6
-427		8231	24.46	16.77	77.9	118	1.0	1.3	3.7	2.0	1.3	2.3
-428		10738	31.38	17.10	80.7	118	1.0	0.7	3.3	2.0	1.3	2.2
Mean		8281.2	25.02	16.43	79.31	152.6	1.7	1.0	4.6	3.1	3.6	3.8
LSD (.05)		2507.3	6.33	2.28	6.52	38.6	1.1	1.2	1.7	1.1	1.9	1.2
C.V. (%)		18.7	15.66	8.59	5.08	15.7	40.8	73.1	23.1	21.4	32.4	20.0
F value		4.6**	5.44**	2.81**	1.79**	7.6**	2.8**	1.3NS	4.1**	6.9**	5.9**	7.8**

TEST 6205. IV-BNYVV RHIZOMANIA EVALUATION OF SOURCES OF RESISTANCE, HARTNELL FIELD, SALINAS, CA, 2005

12 entries x 8 reps, RCB
1-row plots, 11 ft. long

Planted: May 13, 2005
Harvested: November 7, 2005

Variety	RZM Resist	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Soluble Solids	Stand Count	Harv Count	DI	%R (0-3)	%R (0-4)	PM	CLS
			Lbs	Tons	%	%	No.	No.	%	%	%	Score	Score
04-C37	---	Inc. 03-C37	5083	17.23	14.57	18.86	26	25	5.9	14.3	24.6	3.8	2.1
R340	C79-#s	RZM-ER-% R140	7990	26.10	15.41	19.54	29	28	4.7	39.8	54.6	0.6	1.5
R424	C79-2,WB41	RZM-% R724,R324	6877	22.89	15.01	20.00	26	26	3.7	58.7	77.1	2.4	2.1
R425	C79-3,WB42	RZM-% R725,R325	8033	25.83	15.45	19.64	26	26	4.2	46.6	64.2	3.3	2.3
BetaG017R	*Rz2*	7/22/04	12308	38.24	16.09	19.90	23	24	3.4	75.1	83.4	0.6	3.1
Beta4430R	*Rz1*	Resist check, 8/21/03	6399	22.97	13.99	16.79	26	23	5.8	16.3	24.8	1.3	6.9
Roberta	---	Susc. check, 2/25/04	5138	19.63	12.85	16.79	25	21	7.3	6.1	11.0	0.6	4.3
Angelina	*Rz1+Rz2*	Resist check, 2/25/04	11425	36.87	15.41	19.74	28	27	4.2	60.7	70.2	0.8	2.4
R421	*Bvm*	RZM-ER-% R221	8157	27.88	14.63	18.44	27	27	5.2	30.6	44.9	0.9	2.9
R039	Q	Inc. R539 (C39R)	11274	35.80	15.74	19.66	25	25	3.0	79.2	91.3	0.1	2.3
Y477	R22	RZM-ER-% Y277	8068	27.05	14.89	18.50	26	26	5.0	28.0	42.0	0.6	3.6
Y492	*Rz1+*	RZM-ER-% Y292	7438	23.76	15.69	19.83	26	26	5.1	31.6	42.9	1.6	2.5
Mean			8182.6	27.02	14.98	18.97	26.1	25.3	4.8	40.6	52.6	1.4	3.0
LSD (.05)			1375.9	4.21	1.02	0.82	2.7	3.3	0.5	11.7	10.6	1.0	1.2
C.V. (%)			16.9	15.65	6.87	4.35	10.5	12.9	11.1	28.9	20.3	76.3	40.0
F value			23.4**	20.25**	5.99**	15.54**	2.2*	3.3**	40.9**	33.1**	44.9**	9.7**	11.5**

NOTES: Disease was moderately severe and fairly uniform. Appeared that most roots were growing - regrowing under cool fall conditions. Some roots in all entries gave classic rzm symptoms. C39R showed the largest roots, smoothest, least rzm. Many roots in R340/R424/R425 etc. showed severe sprangling, suggestive of *Aphonomyces* or other fungal problems (*Fusarium*), also due to influence of *Bvm*. Systemic BNYVV symptoms were relatively common (5%). Natural *Cercospora* leaf spot occurred and became moderate on susceptible entries.

Earlier when test 6105 was harvested, Dr. Linda Hanson identified *Fusarim* and *Rhizoctonia* on roots with tip rot/crown rot. Most roots showed vascular necrosis that may have been due to *Fusarium*. Plants grew under high nitrogen status and had large, robust canopies.

TEST 6405. HARTNELL FIELD EVALUATION OF GERMPLASM FOR REACTION TO IV-BNYVV, SALINAS, CA, 2005

72 entries x 4 reps, sequential
1-row plots, 11 ft. long

Planted: May 13, 2005
Harvested: November 9, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI Score	%R (0-3) %	%R (0-4) %	PM Score	CLS Score
Hybrid checks												
Beta 6600	From Liu's lot (2/5/02)	9656	29.81	16.13	19.52	28	27	6.2	16.0	19.7	1.5	3.5
Roberta	Susc. check, 2/25/04	6970	28.07	12.48	16.15	24	19	7.0	7.1	14.2	1.0	4.3
Beta 4430R	Resist. check, 8/21/03	6811	25.46	13.27	16.52	28	25	6.0	12.0	21.8	1.0	6.5
Angelina	Resist. check, 2/25/04	9535	31.40	15.18	19.00	29	28	4.5	51.6	58.7	2.3	4.8
Beta G017R	Resist. check, 7/22/04	11222	37.66	14.90	18.45	28	26	3.5	78.3	84.1	1.0	3.8
US H11	Susc. check, 10/14/02	5175	21.43	12.13	16.15	31	27	6.4	15.3	23.3	3.5	2.8
Rizor	Resist. check, 3/29/01	7126	24.51	14.60	19.48	29	26	5.9	12.6	25.6	1.8	3.3
Acclaim	Resist. check, 3/15/05	8356	33.84	12.40	15.25	28	24	6.2	8.4	18.6	1.5	2.8
Lines with Quantitative Resistance												
R039	Inc. R539, (C39R)	11577	39.78	14.52	18.67	27	28	3.7	56.4	76.4	0.3	2.3
R647	RZM R547, (C47R)	10955	33.21	16.50	19.82	25	24	3.8	51.5	73.0	1.0	3.0
03-US75	Inc. 00-US75 (susc.check)	5903	21.75	13.25	17.45	31	26	6.2	8.6	20.4	3.8	3.8
04-C37	Inc. 03-C37 (susc.check)	5789	20.42	14.13	18.58	27	26	5.9	8.9	18.6	4.5	2.0
Lines with *Rz1* Resistance												
R378 Sp	RZM R178, (C78/3)	9042	30.08	15.02	19.17	23	22	5.4	25.4	38.9	0.8	4.0
Y369	RZM-ER-% Y169, (C69/2)	7848	26.31	14.82	18.98	27	27	4.7	42.3	52.3	0.0	1.8
Y391	RZM-ER-% Y191	6955	22.91	15.10	18.92	30	27	5.7	25.3	34.7	0.5	2.5
Y492	RZM-ER-% Y292	7081	23.87	14.77	18.70	28	25	5.7	21.7	31.1	0.8	2.3
4931	RZM 3931aa x A, (C931)	6431	21.01	15.35	18.83	27	23	5.6	21.7	30.2	1.0	3.8
4941	RZM 3941aa x A, (C941)	5884	21.11	13.95	18.17	30	27	5.7	23.2	34.3	0.8	2.8
4747	Inc. 0747 (A,aa)	5048	20.16	12.68	17.17	27	25	5.9	9.4	14.7	2.8	3.0
Z210	Inc. Z010(C),(Polish%S gp)	9526	29.25	16.30	19.52	25	25	6.1	10.2	19.7	1.8	4.3

TEST 6405. HARTNELL FIELD EVALUATION OF GERMPLASM FOR REACTION TO IV-BNYVV, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI Score	%R (0-3) %	%R (0-4) %	PM Score	CLS Score
Lines with *Bvm* Germplasm												
P429	PMR-RZM P329, (CP05)	5825	20.69	14.02	17.65	28	26	6.0	19.6	23.6	0.0	6.3
P430	PMR-RZM P330, (CP06)	7023	23.76	14.80	18.50	30	25	6.3	20.7	23.6	0.0	4.8
P407/8	PMR-RZM-% P207/8, (CP08)	6460	22.28	14.48	18.85	28	25	6.3	8.8	16.7	0.3	4.5
P418-6	PMR-RZM P318-6(Iso), (CP07)	6292	21.01	14.98	19.00	25	28	6.3	9.5	15.0	0.5	4.0
N412 Sp	N312,N212-#(C)aa x A, CN12	6855	24.43	13.95	18.48	21	22	6.6	7.7	13.5	0.3	3.3
N472 Sp	N372,N272-#(C)aa x A, CN72	6473	24.40	13.23	17.42	28	27	7.4	7.2	9.9	1.0	2.3
4921	RZM-ER-% 2921 (A,aa)	6983	23.87	14.57	18.55	29	29	4.5	43.5	54.7	1.0	2.5
0926	RZM-% 8926 (Sp)	6609	23.76	13.88	17.52	27	24	5.8	22.2	29.7	1.5	2.8
R522 Sp	RZM R322(C), (C51)	6162	24.29	12.70	16.73	24	21	5.0	29.0	45.0	1.0	3.3
R926	RZM R826, (C26)	7473	25.78	14.57	18.27	29	25	4.4	52.1	64.2	2.3	3.5
R927	RZM R827, (C27)	6972	23.98	14.45	18.20	30	26	5.0	25.6	46.6	0.5	1.8
R021 Sp	RZM R926, RZM R927, (C26 x C27)	8688	30.13	14.27	17.95	26	27	5.2	27.6	38.7	1.0	2.3
R321	RZM R221, (C26 x C27)	7195	25.41	14.07	17.58	30	28	5.5	25.2	33.2	1.0	2.8
R421	RZM-ER-% R221	6589	23.13	14.15	18.17	29	25	4.8	32.9	45.5	0.8	2.5
Y475	RZM-ER-% Y275	4686	16.13	14.52	18.77	27	25	6.7	4.1	10.0	0.5	2.8
Y477	RZM-ER-% Y277	8538	29.07	14.68	18.90	29	29	4.8	36.1	53.2	1.0	3.0
Hybrids Checks												
Angelina	Resist. check	10874	33.95	16.05	19.88	27	25	4.1	63.2	66.1	1.8	4.3
Beta 4430R	Resist. check	9096	33.15	13.63	16.70	27	27	4.8	33.1	44.0	0.8	7.5
Beta G017R	Resist. check	12190	40.53	15.02	18.67	28	28	3.3	77.8	80.8	0.5	4.8
Beta 6600	From Liu's lot (2/5/02)	8248	27.26	15.07	19.13	28	24	5.9	16.8	27.3	2.0	3.3
Roberta	Susc. check, 2/25/04	5747	23.76	12.02	16.42	23	21	7.0	1.5	11.5	0.8	4.5
Z210H5	C833-5CMS x %S(C)Polish gp	7557	23.52	16.08	19.65	26	24	6.6	10.2	13.9	1.0	3.3
Monohikari	Susc. check, 1/21/03	6385	20.90	15.18	18.50	28	26	6.2	4.5	13.0	1.8	4.0
HM-E17	Susc. check, 4/05	6148	20.26	15.00	18.58	28	26	7.0	1.9	6.1	2.5	1.0

TEST 6405. HARTNELL FIELD EVALUATION OF GERMPLASM FOR REACTION TO IV-BNYVV, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI Score	%R (0-3) %	%R (0-4) %	PM Score	CLS Score
Lines with Bvm Germplasm												
EL-SP7322-0	Inc. SP7322-0	4631	17.50	13.25	16.55	27	23	6.0	9.6	18.8	1.3	0.8
01-EL0204	RZM 00-EL0204	7805	28.75	13.65	17.52	25	29	4.8	35.1	48.4	1.0	3.0
R039	Inc. R539, (C39R)	10414	34.27	15.15	19.35	26	24	3.1	76.2	94.3	0.5	2.3
R647	RZM R547, (C47R)	8455	26.63	15.95	20.45	23	23	3.6	63.0	78.0	1.0	2.3
R421	RZM-ER-% R221	7817	27.02	14.45	18.35	27	27	5.0	33.3	44.3	1.0	3.0
Y367	RZM-ER-% Y167, (C67/2)	8243	26.20	15.73	20.10	29	29	4.4	46.9	62.3	0.0	2.0
Y371	RZM-ER-% Y171, (C72)	6478	21.96	14.77	18.80	29	28	5.3	19.9	35.3	1.3	3.3
P431CT	RZM,CTR R278,R230,P207/8, (CP09CT)	8394	27.82	15.13	19.25	27	26	5.6	28.3	33.6	0.0	4.3
Lines with Bvm germplasm in C37 background												
04-C37	Inc. 03-C37	4994	17.08	14.63	19.02	28	27	6.0	13.9	22.6	3.8	2.8
R324/5	Inc. R824, (C79-2,-3; WB41,42)	6242	20.69	15.00	19.88	29	26	4.6	37.7	55.5	1.5	2.8
R424/5	RZM-% R824, RZM R324/5	6468	21.54	14.90	19.83	28	24	4.2	44.3	60.8	2.0	2.8
R324	Inc. R724, (C79-2, WB41)	5624	19.94	14.10	18.65	29	26	5.0	32.0	43.4	4.0	2.8
R424	RZM-% R724,R324	7310	24.29	15.08	19.83	27	27	4.0	59.2	72.4	3.5	3.0
R325	Inc. R725, (C79-3, WB42)	6165	20.16	15.13	19.25	28	24	4.0	48.8	70.1	3.8	2.3
R425	RZM-% R725, R325, (C79-3, WB42)	6696	22.49	14.77	19.95	30	29	4.3	46.0	65.2	4.3	2.3
R336	RZM-ER-% R136, (C79-8)	5761	20.58	13.92	17.80	30	27	4.7	36.1	48.1	1.8	1.8
R337	Inc. R637, (C79-9, WB151)	7879	24.51	16.15	20.45	30	29	4.2	48.0	66.2	2.3	2.5
R437	RZM-% R637, R337, (C79-9)	9682	28.01	17.23	21.10	29	26	3.7	62.1	75.5	1.3	2.3
R641	RZM R541, R548, (C79-10, WB169)	5670	19.74	14.38	18.25	23	19	5.2	24.3	39.6	2.5	1.5
R642	RZM R542, R549, (C79-11, WB258)	6043	22.02	13.57	17.77	26	21	6.1	17.8	20.0	2.0	2.0

TEST 6405. HARTNELL FIELD EVALUATION OF GERMPLASM FOR REACTION TO IV-BNYVV, SALINAS, CA, 2005 (cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI Score	%R (0-3) %	%R (0-4) %	PM Score	CLS Score
Lines with *Bvm* germplasm in C37 background (cont.)												
R740	RZM-ER R540%, R540-1, R551, (C79-#C)	7636	25.69	14.82	19.17	25	26	5.4	24.2	44.4	3.0	2.0
R940	RZM-ER-% R740, (C79-#C)	7951	26.42	15.13	18.60	30	27	4.8	37.5	49.6	1.0	2.5
R340	RZM-ER-% R140	9101	28.96	15.80	19.75	32	31	5.1	34.2	45.0	1.0	1.8
US H11	Susc. check, 10/14/02	5956	21.54	13.75	17.08	30	26	6.7	8.6	12.4	5.3	2.3
monogerm populations												
4848	RZM-% 2848 (A,aa)	6518	22.38	14.55	18.72	32	32	5.1	24.5	43.1	2.8	3.3
4812M	RZM-% 6812M, 3812m (A,aa)	6304	21.99	14.38	18.95	26	26	4.6	32.8	50.5	1.8	3.0
4819M	RZM-% 6819M, 3819m (A,aa)	3482	16.13	10.70	14.65	24	21	4.9	22.2	50.1	1.0	4.3
4891	RZM,T-O 3891-#(C)mmaa x A	4732	18.57	12.75	17.42	26	22	6.8	6.4	13.7	1.0	3.3
Mean		7283.5	25.01	14.47	18.46	27.4	25.8	5.3	28.6	39.7	1.5	3.1
LSD (.05)		1840.3	6.01	1.19	1.18	4.4	7.1	0.8	15.4	16.6	1.3	2.0
C.V. (%)		18.1	17.26	5.89	4.57	11.5	19.7	11.3	38.7	30.1	63.0	45.4
F value		7.2**	5.81**	7.17**	8.41**	1.9**	1.8**	11.4**	12.2**	13.4**	6.1**	2.8**

NOTES: Tests 6105-6605 were planted at Hartnell field at Salinas, about 5 miles from rhizomania tests at Spence field. The Hartnell field had been in permanent pasture for many years with no known history of sugarbeet production. In June 2003, soild from IV_BNYVV source (Rockwood 156) was incorporated and an inoculation crop grown and disked in. In May 2004, IV_BNYVV tests were grown, but disease pressure was light to moderate. In May 2005, tests 6105 thru 6605 were planted. Disease development was moderate to moderately severe. Under high nitrogen status, canopy growth was robust and green. BNYVV systemic inoculation was common, maybe up to 5% of the plants, particularly in susceptible checks. At harvest, there was evidence that roots were regrowing without rhizomania symptoms. Tip root and vascular necrosis was common and Dr. Linda Hanson isolated both *Fusarium* and *Rhizoctonia* spp.

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI Score	%R (0-3) %	%R (0-4) %	PM Score	CLS Score

NOTES: (cont.)

Powdery mildew was controlled until late and was then score on a scale of 0 to 9 at harvest.

Cercospora leaf spot occurred naturally and became moderately severe on susceptible entries. Leaf spot was scored at harvest on a scale of 0 to 9.

At harvest, topes were flailed to 8-12 inch level; roots were lifted, moist soil shaken loose and laid out; roots were scored on a scale of 0 to 9, where 5 to 9 was considered fully susceptible. After scoring, beets were topped, bagged, washed, weighed, and run thru the sugar lab. % soluble solids were measured by refractometer from the sample brei. Because of rhizomania, some samples could not be read by the polarimeter (too dark or too turbid.)

Coefficients of correlation (r) were calculated:

	DI	%R(0-4)	SY/A	RY/A	%S	%SS	Harv. Count
Disease Index (DI)	-.--	-0.98**	-0.56**	-0.48**	-0.43**	-0.45**	-0.35**
%R (0-4)	-0.98**	-.--	0.58**	0.51**	0.41**	0.45**	0.32*
Gross Sugar Yield (SY/A)	-0.56**	0.58**	-.--	0.95**	0.58**	0.44**	0.39**
Tons Roots/Acre (RY/A)	-0.48**	0.51**	0.95**	-.--	0.31*	0.17NS	0.35**
%S	-0.43**	0.41**	0.58**	0.31*	-.--	0.92**	0.30*
%SS	-0.45**	0.45**	0.44**	0.17NS	0.92**	-.--	0.28*
Harvest Count	-0.35**	0.32*	0.39**	0.35**	0.30*	0.28*	-.–

TEST 6505. PROGENY TEST UNDER IV-BNYVV, HARTNELL FIELD, SALINAS, CA, 2005

48 entries x 2 reps, sequential
1-row plots, 11 ft. long

Planted: May 16, 2005
Harvested: November 10, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI Score	%R (0-3) %	%R (0-4) %	PM Score	CLS Score
Checks												
Roberta	Susc. check, 2/25/04	5524	21.43	12.90	16.60	27	21	7.6	4.3	13.0	2.5	5.5
Beta 4430R	Resist. check, 8/21/03	7997	29.07	13.65	16.80	33	29	6.1	10.6	22.6	2.0	7.5
Beta G017R	7/21/04	10867	38.40	14.25	18.10	29	28	3.9	54.4	72.5	1.0	5.0
Angelina	Resist. check, 2/25/04	8945	31.64	14.10	18.40	25	24	4.5	45.5	56.0	2.5	4.5
FS progenies from WB41 & WB42 Source												
R324 -301	R724 PX	4849	17.63	13.85	18.10	28	27	5.4	15.8	35.6	6.0	3.0
-302		3751	13.79	13.60	18.50	29	28	6.9	3.8	9.1	6.5	6.5
-303		6445	21.85	14.75	19.30	28	25	5.7	10.3	26.3	2.5	2.0
-304		5620	18.82	14.70	20.00	29	20	5.5	28.2	48.2	1.5	1.5
-305		6221	19.52	15.95	21.30	26	26	4.6	39.0	52.8	6.0	2.0
-306		7014	21.71	16.25	21.10	28	27	5.3	33.0	44.7	3.0	3.5
-307		4596	15.49	14.80	19.10	29	28	6.0	20.0	30.8	6.0	2.5
-308		5301	17.19	15.40	19.65	29	30	4.4	44.2	64.8	6.0	1.5
R324 -311	R824 PX	7795	25.67	15.15	19.20	30	28	5.4	27.1	38.0	6.0	4.0
-312		8159	27.16	15.05	19.55	26	24	4.1	60.1	75.7	5.0	2.0
-313		7028	22.28	15.70	20.85	27	25	5.4	42.3	46.3	4.5	2.0
-314		5112	17.40	14.65	19.10	29	29	4.7	24.7	49.3	4.0	2.0
-315		6015	19.37	15.55	19.50	28	25	6.0	16.2	36.5	1.0	4.5
-316		6093	20.16	15.10	19.75	26	26	4.6	47.1	65.5	3.0	2.0
-317		6476	19.33	16.40	19.90	21	17	5.2	32.5	49.6	5.0	2.5
-318		6148	19.41	15.80	19.70	26	25	4.9	33.4	49.8	4.0	3.0
-319		6431	21.43	15.00	19.45	29	30	5.6	23.6	38.7	6.5	1.5
-320		6131	19.00	16.15	21.40	26	26	5.4	27.3	37.3	4.5	2.0
R325 -301	R725 PX	5843	18.14	16.05	21.05	26	25	5.2	32.1	51.5	2.0	4.0
-302		6919	22.30	15.50	20.30	26	27	4.1	48.8	67.9	4.5	2.5

TEST 6505. PROGENY TEST UNDER IV-BNYVV, HARTNELL FIELD, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI Score	%R (0-3) %	%R (0-4) %	PM Score	CLS Score
FS progenies from WB151 source												
R337 -301		7413	23.76	15.60	19.95	28	26	5.4	22.5	42.0	4.5	1.5
-302		7053	21.17	16.60	21.10	21	22	6.7	25.9	30.7	3.5	2.0
-303		10024	32.04	15.60	20.10	24	23	3.2	82.8	93.6	1.5	1.0
-304		7528	21.43	17.45	21.25	28	28	4.1	41.3	72.3	0.0	3.5
-305		8105	25.25	16.05	21.15	30	28	4.6	35.2	62.0	2.0	4.0
-306		8696	27.37	15.90	20.85	28	28	4.1	45.0	66.0	2.0	1.0
-307		8222	25.04	16.40	20.70	25	23	4.5	50.0	65.2	1.5	2.5
-308		11284	37.81	14.95	19.50	21	23	3.2	84.5	95.6	1.0	3.0
FS progenies from R22 source												
Y375 -301		5562	18.03	15.35	19.35	24	23	8.0	0.0	4.2	3.0	2.0
-302		3963	13.71	14.45	18.40	24	22	6.4	9.1	29.5	1.5	2.5
-303		6238	22.21	14.00	18.05	22	21	6.9	10.4	17.8	0.5	4.5
-304		5148	18.03	14.25	17.70	21	21	7.8	2.5	5.0	1.5	3.0
-305		6781	22.91	14.75	18.45	25	25	6.1	11.9	31.9	1.0	1.5
3921 -301	RZM 2921⊗	6991	22.42	15.60	19.75	24	23	5.0	27.3	52.7	2.0	1.5
S_1 & FS progenies from WB41 & WB42 (monogerms)												
3912 -1A	6912M⊗	7188	26.42	13.60	17.05	22	20	4.2	39.3	73.3	3.5	0.5
-3A		5159	19.24	13.35	17.70	21	21	6.1	4.9	18.8	3.5	6.5
3812 -4A	6812M⊗	6896	21.22	16.25	20.95	27	24	4.5	36.7	57.7	3.0	4.5
-7A		5455	17.61	15.50	20.45	23	23	4.5	25.8	58.9	2.5	3.0
3812 -22M	6812M⊗	7059	24.70	14.35	18.30	17	17	4.7	8.7	62.3	2.0	1.0
-23M		6883	25.25	13.65	18.20	20	20	5.2	15.0	28.0	1.5	1.0
3812 -24M	6812M⊗	6540	22.07	14.80	19.05	25	21	4.0	42.9	64.3	5.5	5.0
-25M		6136	20.79	14.75	18.75	25	22	5.4	27.5	39.4	2.5	3.0

TEST 6505. PROGENY TEST UNDER IV-BNYVV, HARTNELL FIELD, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI Score	%R (0-3) %	%R (0-4) %	PM Score	CLS Score
S_1 & FS progenies from WB41 & WB42 (monogerms) (cont.)												
3812 -41m	6812M⊗	8202	26.16	15.70	20.00	21	19	3.7	59.2	75.1	1.5	2.0
-42m		7842	25.67	15.25	19.20	22	19	3.4	71.6	92.3	1.0	1.5
Mean		6784.4	22.47	15.09	19.43	25.3	24.0	5.2	31.3	48.4	3.1	2.9
LSD (.05)		1749.0	5.88	1.41	1.60	6.5	6.8	1.3	22.1	28.4	2.2	2.7
C.V. (%)		12.8	13.02	4.65	4.09	12.8	14.0	12.7	35.0	29.2	34.7	45.6
F value		6.5**	6.37**	3.85**	4.94**	2.2**	1.9*	6.0**	6.7**	5.1**	5.7**	3.0**

NOTES: Full-sib and a few S_1 progenies were randomly produced from breeding lines that have WB41, WB42, and WB151 as sources of resistance. Progenies R324-#s, R325-#s, and R337-#s were produced from C79-2, C79-3, and C79-9 type breeding lines that previously had not been selected for resistance to IV-BNYVV. These breeding lines are approximately 25% WB in a C37 background.

Disease development was good. Many roots were fangy, possibly due to *Bvm* germplasm.

Population 6912 segregates for monogerm and was released as C890-2 and/or C890-3.

TEST 6605. EVALUATION OF PROGENY LINES UNDER IV-BNYVV, HARTNELL FIELD, SALINAS, 2005

22 entries x 2 reps, sequential
1-row plots, 11 ft. long

Planted: May 16, 2005
Harvested: November 10, 2005

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Soluble Solids	Stand Count	Harv Count	DI	%R (0-3)	%R (0-4)	PM	CLS
		Lbs	Tons	%	%	No.	No.	Score	%	%	Score	Score
Checks												
US H11	Susc. check	3834	17.19	11.10	15.10	29	21	7.6	0.0	2.4	5.0	5.5
Beta 4430R	Resist. check, 8/21/03	6908	27.58	12.05	15.45	28	25	6.6	12.1	17.2	1.0	8.0
Angelina	Resist. check, 2/25/04	10382	35.01	14.85	17.85	31	30	4.2	58.6	69.4	2.0	7.5
Roberta	Susc. check, 2/25/04	4749	18.74	12.15	15.15	25	16	8.2	0.0	0.0	1.0	3.0
Beta G017R	7/22/04	10911	35.82	15.30	19.45	26	25	3.8	61.3	77.8	1.0	4.0
Progeny lines												
Y367-5	RZM Y167-5	7597	26.31	14.20	18.50	28	24	6.0	20.7	27.7	0.0	3.0
3927-4	RZM 2927-4, (C927-4)	6161	23.55	13.00	16.80	33	31	6.2	17.6	32.6	2.0	5.0
R378-6	RZM R178-6	6588	23.55	13.50	17.35	22	19	5.7	27.8	43.9	1.0	4.5
R380-21	RZM R180-21	6408	22.49	14.10	18.35	27	23	6.3	20.4	30.8	4.0	5.0
Y267-21	Inc. Y067-21	8577	28.01	15.30	20.10	30	28	4.6	36.3	58.0	1.0	2.0
Y267-24	Inc. Y067-24	9148	32.31	14.20	18.60	28	27	5.4	30.4	37.9	0.5	3.0
Y267-34	Inc. Y067-34	7824	27.58	14.20	18.70	27	24	4.9	25.5	57.8	2.0	2.5
Y271-14	Inc. Y071-14	6822	23.76	14.30	19.30	29	29	7.1	5.2	8.7	2.5	5.0
R480-6	RZM R280-6	4589	16.55	13.85	18.10	27	22	8.1	0.0	2.2	1.5	4.5
R443-14	RZM R243-14	6417	22.70	14.15	18.20	29	26	6.3	5.7	19.4	0.0	2.0
4933-14	2933-14aa x A											
Z431-18	Z131-18aa x A	4865	18.31	13.25	17.30	24	22	6.7	8.9	17.8	3.0	2.5
N412-10	Inc. N212-10	8452	29.46	14.20	18.40	22	23	6.0	15.0	22.5	1.0	5.0
N412-11	Inc. N212-11	4156	15.38	13.55	17.90	26	22	7.4	0.0	0.0	1.5	1.5
N412-205	Inc. N212-205	3615	12.94	13.65	17.95	23	24	7.3	6.8	11.0	1.5	1.5
N472-230	Inc. N272-230	4824	18.80	12.80	17.10	24	23	7.6	2.2	13.0	4.0	2.0
N472-233	Inc. N272-233	3772	15.91	11.70	16.40	31	27	8.3	4.0	4.0	2.5	1.0
4926-11-1-3	Inc. 2926-11-1-3	6232	19.03	15.90	19.50	30	29	7.1	3.5	13.7	4.0	4.5
4926-11-3-22	Inc. 2926-11-3-22 (CN926-3-22)											

TEST 6605. EVALUATION OF PROGENY LINES UNDER IV-BNYVV, HARTNELL FIELD, SALINAS, 2005 (cont.)

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Soluble Solids	Stand Count	Harv Count	DI	%R (0-3)	%R (0-4)	PM	CLS
		Lbs	Tons	%	%	No.	No.	Score	%	%	Score	Score
Mean		6492.3	23.23	13.70	17.80	27.0	24.3	6.4	16.5	25.8	1.9	3.8
LSD (.05)		3880.5	11.30	2.28	2.27	7.2	7.6	1.9	26.7	30.7	3.1	5.1
C.V. (%)		28.7	23.40	8.00	6.12	12.8	15.1	14.4	78.0	57.2	79.0	65.4
F value		2.6*	2.82*	2.42*	3.19*	1.5NS	2.0NS	3.9**	3.9**	4.9**	1.7NS	1.2NS

NOTES: The entries in Test 6605 were selected after being evaluated under nondiseased and normal-BNYVV conditions at Salinas and Brawley. They were evaluated to see if by chance resistance to IV-BNYVV had been transferred to advanced full-sib or S_1 progeny lines. This does not appear to have happened. Most of these progeny lines should be *Rz1*.

TEST 6305. PROGENY TEST OF Y91 FULL SIBS UNDER IV-BNYVV, HARTNELL FIELD, SALINAS, CA, 2005

24 entries x 2 reps, sequential
1-row plots, 11 ft. long

Planted: May 13, 2005
Harvested: November 8, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI Score	%R (0-3) %	%R (0-4) %	PM Score	CLS Score
FS progenies from Y91												
Y491 -401	Y391 PX	5335	17.99	14.85	19.00	24	19	6.8	10.8	16.1	0.5	4.5
-402		6497	22.07	14.75	19.30	25	25	6.4	16.4	20.2	0.0	4.5
-403		5553	19.94	13.70	17.80	30	29	6.1	17.2	31.0	1.5	5.0
-404		6247	19.73	15.85	19.45	27	27	7.6	8.7	12.5	0.5	3.0
-405		6253	19.73	15.70	19.50	21	21	6.2	16.7	23.8	0.5	0.5
-406		6307	21.01	15.00	18.90	27	27	6.5	11.2	20.6	2.0	1.5
-407		6573	21.30	15.30	19.00	25	23	6.5	6.5	21.7	2.0	3.5
-408		7036	23.76	14.80	18.80	27	27	6.0	20.9	30.4	0.0	1.5
-409		6299	20.37	15.45	20.50	24	21	6.0	21.4	33.3	0.0	3.0
-410		6458	22.28	14.55	18.45	27	24	6.9	14.3	18.3	0.5	2.0
-411		6207	19.94	15.45	19.45	27	25	5.6	26.6	39.3	1.0	2.0
-412		6139	20.79	14.80	18.95	26	27	6.5	7.5	17.0	1.5	1.0
-413		5091	16.13	15.60	20.20	25	25	6.9	12.0	20.1	1.5	1.5
-414		6619	22.91	14.35	18.35	25	23	7.3	2.6	12.7	1.5	2.0
-415		7725	23.55	16.40	20.60	25	25	7.1	12.8	22.5	0.0	2.0
-416		6943	20.67	16.80	20.95	25	22	5.5	16.3	50.9	0.0	1.5
-417		7560	23.98	15.75	20.15	26	22	6.2	17.9	30.2	0.0	0.5
-418		5455	18.88	14.45	18.25	25	23	6.0	15.9	22.5	0.0	0.5
-419		5433	17.61	15.40	19.30	33	29	6.5	12.8	20.0	0.0	1.5
-420		5116	15.91	16.05	19.85	25	28	5.7	22.4	33.6	0.5	3.5
-421		7480	24.19	15.40	19.30	30	29	6.4	17.4	26.5	0.0	1.0
-422		6877	22.91	15.00	19.00	23	23	7.1	11.1	13.9	0.0	0.5
-423		7720	24.72	15.65	19.80	26	26	7.1	10.4	15.2	0.5	1.0
-424		6747	22.33	15.30	19.40	24	22	6.6	12.4	21.8	0.5	0.5

TEST 6305. PROGENY TEST OF Y91 FULL SIBS UNDER IV-BNYVV, HARTNELL FIELD, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Soluble Solids	Stand Count	Harv Count	DI	%R (0-3)	%R (0-4)	PM	CLS
		Lbs	Tons	%	%	No.	No.	Score	%	%	Score	Score
Mean		6402.9	20.95	15.27	19.34	25.7	24.4	6.5	14.3	23.9	0.6	2.0
LSD (.05)		2440.5	8.27	1.22	1.54	7.0	6.9	1.0	21.6	19.1	1.2	2.4
C.V. (%)		18.4	19.08	3.87	3.84	13.1	13.7	7.7	73.2	38.6	96.5	57.3
F value		0.9NS	0.76NS	2.70*	2.17*	1.1NS	1.3NS	2.4*	0.6NS	2.0NS	2.8*	2.9*

NOTES: Test 6305 is composed of a random set of full-sib progenies from breeding line Y391. Most of these progenies should have *Rz1*. These progenies were grown as border rows between tests 6205 and 6405.

TEST 1405. EVALUATION OF PMR/SBCN RESISTANT LINES AND PROGENIES FOR PERFORMANCE & PM, SALINAS, CA, 2005

48 entries x 4 reps., sequential
1-row plots, 11 ft. long

Planted: April 20, 2005
Harvested: October 6, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/ 100' No.	Powdery Mildew Score 08/4	09/7	10/6	Mean
Checks										
04-C37	Inc. 03-C37	10764	33.49	16.00	78.4	134	4.8	7.5	4.3	5.9
P427	PMR-RZM P327, (CP03)	13556	40.31	16.83	80.5	130	0.8	2.0	2.5	1.7
P428	PMR-RZM P327, (CP04)	16599	49.62	16.80	80.8	139	0.3	1.3	1.0	0.8
US H11	11/3/99	12229	37.50	16.32	80.4	139	5.3	7.8	4.0	6.1
Angelina	2/25/04	16178	45.38	17.80	81.3	134	4.8	8.0	8.0	7.1
R378 (Sp)	RZM R178, (C78/3)	13484	39.14	17.22	81.9	145	2.3	6.0	2.8	4.1
P429	PMR-RZM P329, (CP05)	13916	41.92	16.55	81.6	132	0.3	1.3	0.8	0.8
P430	PMR-RZM P330, (CP06)	14703	42.92	17.10	80.4	130	1.0	2.0	0.8	1.3
N412 (Iso)	PMR-RZM N312 (A,aa)	15678	47.06	16.65	80.6	141	0.5	2.0	0.8	1.0
N412 (Sp)	N312,N212-#(C)aa x A, (CN12)	15053	45.14	16.63	78.5	130	0.8	2.0	1.0	1.2
N472 (Iso)	RZM-NR N372 (A,aa)	15023	45.54	16.48	79.3	127	0.8	2.0	1.8	1.5
N472 (Sp)	N372, N272-#(C)aa x A, (CN72)	13555	40.53	16.75	80.5	120	0.8	3.3	2.5	2.1
Roberta	2/25/04	16265	45.75	17.77	82.6	132	2.3	4.8	2.8	3.3
P407/8	PMR-RZM-% P207/8, (CP07)	13988	41.27	16.90	81.1	127	0.8	2.0	1.3	1.2
P407/8D	Inc. P307/8-1,-2,-3,-4	13048	38.49	16.95	80.4	136	1.3	3.3	2.0	2.2
P418-6	PMR-RZM P318-6 (Iso), (CP08)	11823	35.87	16.42	79.9	125	1.5	3.0	1.5	1.9
Progeny lines										
N412-6	Inc. N212-6	8782	25.80	17.02	77.7	130	0.8	4.0	1.3	1.8
N412-10	Inc. N212-10	12164	36.27	16.75	77.1	120	1.0	3.8	3.0	2.5
N412-11	Inc. N212-11	12116	34.80	17.40	79.5	139	0.5	3.0	1.0	1.5
N412-13	Inc. N212-13	6437	19.95	16.17	77.8	143	0.0	0.0	0.0	0.0
N412-202	Inc. N212-202	11806	36.88	16.00	80.1	150	1.5	4.3	2.8	3.0
N412-203	Inc. N212-203	13156	40.16	16.38	80.5	132	0.0	0.8	0.3	0.3
N412-205	Inc. N212-205	8821	27.08	16.25	76.5	120	0.8	4.8	6.8	4.3
4747	Inc. 0747 (A,aa)	11342	33.84	16.78	82.2	120	3.0	6.5	5.0	5.4
4921	RZM-ER-% 2921 (A,aa)	13833	40.28	17.17	80.7	132	2.3	5.5	4.5	4.6
N472-230	Inc. N272-230	10291	33.72	15.27	79.5	134	1.3	4.5	4.8	3.8

TEST 1405. EVALUATION OF PMR/SBCN RESISTANT LINES AND PROGENIES FOR PERFORMANCE & PM, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/100' No.	Powdery Mildew Score 08/4	09/7	10/6	Mean
Progeny lines	(cont.)									
N472-231	Inc. N272-231	13195	40.22	16.40	79.0	136	1.0	4.0	3.3	2.8
N472-233	Inc. N272-233	11425	37.89	15.18	77.1	141	2.0	4.5	3.5	3.7
4926-11-1-3	Inc. 2926-11-1-3	11012	31.78	17.35	78.7	127	0.5	4.3	7.3	4.0
4926-11-3-22	Inc. 2926-11-3-22	10646	30.23	17.58	80.3	127	0.0	3.0	3.5	2.1
4926-11-7-61	Inc. 2926-11-7-61	10154	28.21	18.02	80.1	118	0.3	3.5	5.3	2.9
4926-11-10-91	Inc. 2926-11-10-91	9860	27.61	17.88	79.4	114	0.5	3.3	5.0	2.9
3927-4	RZM 2927-4 (A,aa), (C927-4)	12386	38.09	16.27	79.3	145	2.8	7.0	4.5	5.0
4927-202	Inc. 2927-4-202	12253	35.47	17.27	80.4	134	2.8	6.0	2.3	4.1
R443-14	RZM R243-14	14151	42.52	16.65	83.0	141	1.0	3.5	1.8	2.0
Y471-14	RZM Y271-14	12099	34.66	17.45	80.9	152	1.5	5.0	4.3	4.0
Breeding lines										
Y467-21	RZM Y267-21	13738	39.50	17.38	80.3	139	0.8	4.0	2.5	2.6
R336	RZM-ER-% R136	11899	37.06	15.98	78.6	130	3.0	5.3	1.8	3.8
Y475	RZM-ER-% Y275	13380	39.50	16.92	81.2	145	1.3	3.8	1.8	2.4
Y477	RZM-ER-% Y277	12587	37.28	16.85	81.5	127	2.5	5.5	3.5	4.1
P431CT	RZM,CTR R278,P230,P207/8	16059	45.34	17.73	82.6	136	0.8	1.8	1.0	1.2
N424	RZM N324-#(C)(g) (A,aa)	9596	31.12	15.35	75.9	120	1.8	5.0	4.5	4.2
Z210	Inc. Polish %S(C)	13100	33.61	19.58	83.7	111	1.8	4.5	4.5	4.2
R039	Inc. R539, (C39R)	11585	35.47	16.25	82.4	136	1.0	3.5	2.0	2.2
R481-22	RZM R181-22, (C81-22)	13181	37.69	17.42	82.0	141	1.5	4.5	1.8	2.6
R421	RZM-ER-% R221	12613	38.29	16.48	80.1	145	2.3	5.0	2.0	3.1
Beta 4430R	8/21/03	16327	47.16	17.35	85.3	134	2.3	4.3	2.8	3.4
Phoenix	9/12/03	13034	39.26	16.60	83.3	136	2.8	6.3	5.0	5.2
Mean		12685.2	37.64	16.84	80.3	132.9	1.5	4.0	2.9	3.0
LSD (.05)		2438.1	6.89	0.87	2.7	21.3	1.2	1.3	2.1	1.2
C.V. (%)		13.8	13.09	3.68	2.4	11.5	55.0	22.9	50.6	28.1
F value		6.1**	6.10**	6.20**	3.9**	1.5NS	8.7**	16.0**	6.2**	14.8**

TEST 2505. EVALUATION UNDER RHIZOMANIA OF PMR/SBCN RESISTANT LINES AND PROGENIES FOR PERFORMANCE & PM, SALINAS, CA, 2005

48 entries x 4 reps., sequential
1-row plots, 11 ft. long

Planted: May 3, 2005
Harvested: November 18, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/ 100' No.	Root Rot %	Powdery Mildew Score	SBCN Counts 11/05
Checks									
04-C37	Inc. 03-C37	4355	13.24	16.48	78.9	177	0.0	3.8	
P427	PMR_RZM P327,(CP03)	8787	24.79	18.15	84.1	161	0.0	1.0	
P428	PMR-RZM P328,(CP04)	11245	33.66	16.70	76.8	170	0.0	1.0	136
US H11	11/3/97	5240	17.06	15.23	78.7	173	0.0	3.3	2040
Angelina	2/25/04	12821	35.05	18.27	82.4	166	0.0	3.0	
R378(Sp)	RZM R178,(C78/3)	11144	28.58	19.48	85.6	182	0.0	2.0	
P429	PMR-RZM P329,(CP05)	9633	27.41	17.58	79.3	191	0.0	0.3	
P430	PMR-RZM P330,(CP06)	11732	32.86	17.93	78.7	177	1.5	0.3	
N412 (Iso)	PMR-RZM N312 (A,aa)	9989	29.43	17.00	79.3	173	0.0	0.5	
N412 (Sp)	N312,N212-#(C)aa x A,(CN12)	13079	35.28	18.60	82.4	180	0.0	0.8	168
N472 (Iso)	RZM-NR N372 (A,aa)	12030	33.46	17.95	79.6	191	0.0	0.8	
N472 (Sp)	N372, N272-#(C)aa x A,(CN72)	11456	34.07	16.80	73.8	177	0.0	1.0	473
Roberta	2/25/04	5987	18.16	16.42	81.5	173	0.0	2.0	
P407/8	PMR-RZM-% P207/8,(CP07)	12826	34.37	18.63	83.2	189	0.0	0.8	
P407/8D	Inc. P307/8-1,-2,-3,-4	10196	27.21	18.75	80.5	189	0.0	1.0	
P418-6	PMR-RZM P318-6 (Iso),(CP08)	10265	30.03	17.08	78.5	184	0.0	0.8	
Progeny lines									
N412-6	Inc. N212-6	2379	7.36	16.10	74.4	198	0.0	1.8	
N412-10	Inc. N212-10	9454	27.82	17.00	73.2	202	0.0	0.3	
N412-11	Inc. N212-11	8852	23.73	18.65	78.4	200	0.0	0.0	87
N412-13	Inc. N212-13	2971	9.47	15.65	71.3	175	0.0	0.3	1260
N412-202	Inc. N212-202	9077	27.62	16.27	74.7	186	0.0	1.5	
N412-203	Inc. N212-203	8593	24.19	17.55	80.9	193	0.0	0.5	

TEST 2505. EVALUATION UNDER RHIZOMANIA OF PMR/SBCN RESISTANT LINES AND PROGENIES FOR PERFORMANCE & PM, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/ 100' No.	Root Rot %	Powdery Mildew Score	SBCN Counts 11/05
Progeny lines (cont.)									
N412-205	Inc. N212-205	7823	21.37	18.27	76.0	180	0.0	0.8	
4747	Inc. 0747 (A,aa)	6468	19.68	16.63	83.3	166	0.0	4.8	
4921	RZM-ER-% 2921 (A,aa)	13352	34.07	19.40	85.4	180	0.0	3.0	
N472-230	Inc. N272-230	5311	18.90	14.10	68.5	170	5.6	1.5	
N472-231	Inc. N272-231	10802	30.84	17.52	81.0	166	0.0	1.3	
N472-233	Inc. N272-233	7980	25.60	15.63	75.4	191	0.0	1.8	
4926-11-1-3	Inc. 2926-11-1-3	8258	25.19	16.50	77.7	182	0.0	1.3	
4926-11-3-22	Inc. 2926-11-3-22	8088	22.78	17.95	76.3	198	0.0	1.0	20
4926-11-7-61	Inc. 2926-11-7-61	6483	18.07	17.85	78.1	205	0.0	1.0	
4926-11-10-91	Inc. 2926-11-10-91	9111	24.79	18.40	79.9	191	0.0	0.8	
3927-4	RZM 2927-4(A,aa),(C927-4)	8644	25.91	16.65	78.1	200	0.0	3.3	
4927-202	Inc. 2927-4-202	7995	22.79	17.65	83.1	195	9.8	1.3	171
R443-14	RZM R243-14	12353	34.27	18.03	80.5	193	0.0	1.0	
Y471-14	RZM Y271-14	11275	30.54	18.50	79.5	180	0.0	2.8	
Breeding lines									
Y467-21	RZM Y267-21	13052	32.09	20.48	88.1	175	0.0	1.0	
R336	RZM-ER-% R136	10908	30.84	17.77	82.6	184	1.1	2.0	
Y475	RZM-ER-% Y275	9932	27.62	18.00	77.1	191	0.0	1.3	
Y477	RZM-ER-% Y277	11294	31.26	18.02	81.2	195	0.0	1.8	
P431CT	RZM,CTR R278,P230,P207/8	12901	35.07	18.40	79.4	186	0.0	1.0	
N424	RZM N324-#(C)(g)(A,aa)	7002	19.51	18.02	82.6	182	0.0	1.5	
Z210	Inc. Polish %S(C)	6389	17.15	18.80	75.7	177	0.0	3.8	
R039	Inc. R539,(C39R)	9855	28.42	17.45	80.6	184	0.0	1.0	

TEST 2505. EVALUATION UNDER RHIZOMANIA OF PMR/SBCN RESISTANT LINES AND PROGENIES FOR PERFORMANCE & PM, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	RJAP	Beets/ 100'	Root Rot	Powdery Mildew	SBCN Counts
		Lbs	Tons	%	%	No.	%	Score	11/05
Breeding lines	(cont.)								
R481-22	RZM R181-22,(C81-22)	11000	29.83	18.45	80.9	193	0.0	1.0	
R421	RZM-ER-% R221	12959	33.22	19.52	89.1	189	0.0	1.0	
Beta 4430R	8/21/03	10922	31.04	17.60	80.3	177	0.0	1.0	496
Phoenix	9/12/03	10402	31.04	16.85	79.4	168	0.0	2.3	
Mean		9340.7	26.60	17.60	79.5	183.4	0.4	1.5	
LSD (.05)		1944.7	4.92	1.97	7.7	25.6	3.8	0.9	
C.V. (%)		14.8	13.22	8.02	7.0	10.0	725.9	41.5	
F value		15.3**	15.26**	2.91**	2.1**	1.4NS	1.4NS	12.0**	

NOTES: Soil cores were taken early July for entries US H11 and Beta 4430 and averaged 633 and 170 eggs+larvae/ 100g soil, respectively. Soil was sampled at harvest in mid-November and composited by variety.

TEST 1305. EVALUATION OF MONOGERM LINES & POPULATIONS, SALINAS, CA, 2005

48 entries x 4 reps., sequential
1-row plots, 11 ft. long

Planted: April 20, 2005
Harvested: October 10, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	PM Score
Checks								
04-C790-15m	Inc. 00-C790-15	13222	40.31	16.40	19.73	83.1	136	1.3
04-C790-15H0m	99-C79-68CMS x Inc. 00-C790-15	15051	44.34	16.98	20.75	82.0	127	1.5
2833-5HO (Sp)	1833-5HO x RZM,T-O 1833-5-#(C)	13403	37.49	17.92	22.25	80.6	127	2.8
2833-5 (Sp)	RZM,T-O 1833-5-#(C)mmaa x A	12940	36.68	17.65	21.88	80.7	127	4.0
99-C790-68	Inc. U88-790-68	12336	34.06	18.10	20.38	88.8	139	2.0
0546	Inc. 97-C546, (C546)	10728	32.05	16.73	20.67	81.1	139	1.8
0562	Inc. 97-C562, (C562)	10160	31.44	16.20	20.27	79.9	123	2.5
2833-5NB	NB-RZM-% 0833-5(Sp)aa x A	11706	32.52	18.00	21.95	82.0	132	2.5
Monogerm lines, CMS's, and F_1CMS's								
4842-226H5	2833-5HONB x A	14803	42.15	17.58	22.02	79.8	98	2.0
4842-226m	Inc. 2842-226 (A,aa)(T-O)	9375	26.40	17.83	22.30	80.0	130	1.0
4842-256m	Inc. 2842-256 (A,aa)(T-O)	11099	33.05	16.80	20.92	80.3	143	3.5
4842-256H5	2833-5HONB x A	13355	37.29	17.90	21.65	82.7	105	4.0
4842-262H5	2833-5HONB x A	12704	36.17	17.58	21.70	81.0	109	2.5
4842-262m	Inc. 2842-262 (A,aa)(T-O)	10867	31.54	17.20	21.42	80.2	134	2.5
4837-6-203m	Inc. 2837-6-203 (A,aa)(T-O)	11016	32.17	17.13	20.85	82.2	125	2.3
4837-6-203H5	2833-5HONB x A	15952	46.45	17.17	20.85	82.4	125	3.0
4836-13H5	2833-5HONB x A	16915	45.95	18.42	22.85	80.6	136	3.0
4836-13m	RZM-T-O 3836-13-#(C)(A,aa)	11197	31.69	17.70	21.95	80.6	114	1.5
N465-9m	Inc. N365-9-#(C)(g)	6558	25.70	12.77	16.48	77.5	107	3.3
N465-9H0m	N365-9HO(g) x Inc. N365-9-#(C)(g)	11788	39.20	15.00	18.67	80.4	114	5.0
N465-31H0m	N365-31HO(g) x N365-31-1(g)	12444	39.42	15.90	19.88	79.9	116	3.3
N465-31-1m	RZM N365-31(g) (1 plant)	12614	42.26	14.95	18.20	82.2	123	1.5
N465-31m	Inc. N365-31(g)	7062	25.19	13.90	17.13	81.1	64	2.5
N465m	RZM N365,N367(g)	11169	37.47	14.88	18.13	82.1	114	3.0
N469m	RZM N369(g)	11343	33.92	16.73	21.08	79.5	130	3.3
N469HOm	RZM N369HO x RZM N369(g)	11599	35.92	16.15	19.70	82.0	95	4.0

TEST 1305. EVALUATION OF MONOGERM LINES & POPULATIONS, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	PM Score
Monogerm lines, CMS's, and F_1CMS's (cont.)								
4842(Iso)m	RZM-% 2842 (A,aa)	12647	37.49	16.88	21.05	80.2	139	5.0
3842	RZM 2842(C)mmaa x A	12500	36.88	16.95	21.32	79.5	134	4.5
3869	1869(C)mmaa x A	14796	44.91	16.48	20.10	82.1	127	4.0
2790	0790mmaa x A	14883	42.73	17.42	21.02	83.0	145	3.3
4891m	RZM,T-O 3891-#(C)mmaa x A	15084	42.33	17.85	22.07	80.8	130	2.5
4891H0m	2833-5HO x A	13114	38.58	17.00	20.88	81.5	127	2.3
4843H0m	3842HO x A	14155	41.12	17.27	21.48	80.5	130	3.8
4843m	RZM,T-O 3843-#(C)mmaa x A	13265	37.19	17.80	21.17	84.4	116	2.3
4846m	RZM,T-O 3846-3845-#(C)mmaa x A	15142	44.54	17.00	21.27	80.0	139	4.0
4846H0m	3842HO x A	13599	42.07	16.15	20.20	80.0	125	4.0
4850H5	2833-5HO x A	14491	39.71	18.23	22.30	81.8	139	4.0
4850M	Inc. 2252-2MmAa (A,aa)	12592	33.70	18.75	22.88	82.0	136	3.0
4851M	Inc. 2252-5MmAa (A,aa)	14560	41.22	17.70	22.38	79.1	130	2.8
4851H5	2833-5HO x A	15804	42.93	18.40	22.22	82.8	152	2.3
4835m	RZM-% 2835 (A,aa)	13394	40.51	16.70	20.80	80.3	130	2.5
4836m	RZM-% 2836 (A,aa)	13006	38.86	16.70	21.32	78.3	125	8.3
4837m	RZM-% 2837 (A,aa)	12609	35.47	17.77	21.57	82.4	116	7.8
4892m	RZM-% 2790H7 (A,aa)	13666	40.02	17.08	21.35	80.0	116	3.5
4848m	RZM-% 2848 (A,aa)	13234	38.07	17.40	21.45	81.2	134	3.0
4812m	RZM-% 6812,3812 (A,aa)	13990	43.33	16.15	20.20	79.9	148	4.5
4819M	RZM-% 6819,3819 (A,aa)	11739	36.48	16.08	20.10	80.0	130	2.8
3849m	RZM 2251-2255(C)mmaa x A	15021	43.13	17.40	21.40	81.4	132	3.3
Mean		12806.2	37.75	16.93	20.88	81.1	125.6	3.2
LSD (.05)		2045.8	5.93	1.12	1.38	4.1	32.2	2.0
C.V. (%)		11.4	11.24	4.74	4.74	3.6	18.3	45.8
F value		7.9**	5.89**	8.41**	7.60**	1.4NS	1.8*	3.7**

NOTES: See test 3005 under rhizomania conditions.

TEST 3005. EVALUATION OF MONOGERM LINES & POPULATIONS UNDER RHIZOMANIA, SALINAS, CA, 2005

48 entries x 4 reps., sequential
1-row plots, 11 ft. long

Planted: May 3, 2005
Harvested: November 16, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	PM Score
Checks									
04-C790-15m	Inc. 00-C790-15	7638	23.18	16.42	21.30	77.2	195	0.0	1.3
04-C790-15HOm	99-C790-68CMS x Inc. 00-C790-15	7874	23.38	16.80	20.90	80.3	175	1.3	2.5
2833-5HO(Sp)	1833-5HO x RZM,T-O 1833-5-#(C)	10040	27.21	18.42	22.72	81.1	152	3.2	1.5
2833-5(Sp)	RZM,T-O 1833-5-#(C)mmaa x A	10730	26.35	20.52	23.13	88.7	184	0.0	1.3
99-C790-68	Inc. U88-790-68	6971	20.87	16.52	21.05	78.5	184	0.0	1.3
0546	Inc. 97-C546,(C546)	2770	8.82	16.65	20.65	80.6	189	0.0	1.8
0562	Inc. 97-C562,(C562)	2611	7.48	17.20	22.50	76.4	159	0.0	1.3
2833-5NB	NB-RZM-% 0833-5(Sp)aa x A	7361	21.37	17.52	23.10	75.7	198	1.2	2.3
Monogerm lines, CMS's, and F_1CMS's									
4842-226H5	2833-5HONB x A	11088	27.62	20.08	23.85	84.2	148	0.0	1.5
4842-226m	Inc. 2842-226 (A,aa)(T-O)	4604	11.93	19.33	24.42	79.1	202	0.0	1.0
4842-256m	Inc. 2842-256 (A,aa)(T-O)	6757	20.00	16.83	21.15	79.5	193	1.1	3.0
4842-256H5	2833-5HONB x A	11133	32.23	17.27	21.85	79.1	184	0.0	2.5
4842-262H5	2833-5HONB x A	10258	28.02	18.38	22.65	81.2	168	0.0	1.5
4842-262m	Inc. 2842-262 (A,aa)(T-O)	6460	18.84	17.13	22.38	76.5	193	0.0	1.5
4837-6-203m	Inc. 2837-6-203 (A,aa)(T-O)	6724	19.75	17.13	22.80	75.1	189	0.0	1.0
4837-6-203H5	2833-5HONB x A	11135	31.65	17.65	22.20	79.5	180	0.0	2.0
4836-13H5	2833-5HONB x A	12077	33.66	17.98	23.10	77.8	180	0.0	1.5
4836-13m	RZM-T-O 3836-13-#(C) (A,aa)	8028	22.88	17.55	23.35	75.2	150	0.0	1.0
N465-9m	Inc. N365-9-#(C)(g)	4629	16.69	13.90	18.35	75.7	148	0.0	1.0
N465-9HOm	N365-9HO(g) x Inc. N365-9-#(C)(g)	12351	38.48	16.13	20.30	79.4	105	0.0	1.3
N465-31HOm	N365-31HO(g) x N365-31-1(g)	9134	29.93	15.43	20.00	77.1	173	0.0	1.8
N465-31-1m	RZM N365-31(g) (1 plant)	9011	28.62	15.75	19.83	79.5	186	0.0	1.3
N465-31m	Inc. N365-31(g)	5431	18.90	14.23	18.05	78.9	75	0.0	1.0
N465m	RZM N365,N367(g)	8344	27.92	14.98	19.08	78.6	191	0.0	1.8
N469m	RZM N369(g)	7099	22.13	16.25	20.47	79.8	168	1.2	1.3
N469HOm	RZM N369HO x RZM N369(g)	11249	33.28	16.88	21.55	78.3	170	3.8	1.8

TEST 3005. EVALUATION OF MONOGERM LINES & POPULATIONS UNDER RHIZOMANIA, SALINAS, CA, 2005 (cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	PM Score
Monogerm lines, CMS's, and F_1CMS's (cont.)									
4842(Iso)m	RZM-% 2842 (A,aa)	8303	25.40	16.42	21.45	76.5	195	0.0	2.0
3842	RZM 2842(C)mmaa x A	7474	22.22	16.77	22.30	75.3	170	0.0	2.3
3869	1869(C)mmaa x A	10080	29.83	16.95	21.27	79.7	191	0.0	1.5
2790	0790mmaa x A	7535	22.37	16.85	20.95	80.4	182	0.0	1.3
4891m	RZM,T-O 3891-#(C)mmaa x A	10223	28.02	18.25	22.20	82.3	175	2.5	1.3
4891HOm	2833-5HO x A	8402	24.27	17.40	22.67	76.7	168	1.5	1.3
4843HOm	3842HO x A	9193	26.41	17.48	22.07	79.3	175	0.0	1.5
4843m	RZM,T-O 3843-#(C)mmaa x A	8671	24.87	17.50	22.02	79.5	159	0.0	1.5
4846m	RZM,T-O 3846-3845-#(C)mmaa x A	9022	25.80	17.50	22.05	79.4	186	0.0	2.5
4846HOm	3842HO x A	9321	27.13	17.17	21.45	80.1	175	1.3	2.8
4850H5	2833-5HO x A	10824	29.37	18.55	23.38	79.4	180	0.0	1.8
4850M	Inc. 2252-2MmAa (A,aa)	10039	25.74	19.52	24.00	81.4	180	1.2	1.3
4851M	Inc. 2252-5MmAa (A,aa)	9873	25.19	19.52	23.83	81.9	164	0.0	1.0
4851H5	2833-5HO x A	11344	31.85	17.88	21.77	82.5	184	0.0	1.5
4835m	RZM-% 2835 (A,aa)	10935	30.62	17.95	22.27	80.6	186	0.0	1.0
4836m	RZM-% 2836 (A,aa)	8164	25.80	15.85	20.63	76.9	189	0.0	2.8
4837m	RZM-% 2837 (A,aa)	7715	22.58	17.17	21.92	78.3	180	0.0	3.8
4892m	RZM-% 2790H7 (A,aa)	10108	28.42	17.77	22.25	79.9	189	0.0	2.3
4848m	RZM-% 2848 (A,aa)	10575	29.43	17.95	22.02	81.5	193	0.0	1.8
4812m	RZM-% 6812,3812 (A,aa)	10240	29.83	17.13	21.45	79.9	184	2.0	2.5
4819M	RZM-% 6819,3819 (A,aa)	5567	18.00	15.35	19.70	77.9	141	0.0	1.0
3849m	RZM 2251-2255(C)mmaa x A	11811	31.85	18.55	22.65	81.9	195	0.0	2.0
Mean		8686.0	25.13	17.26	21.77	79.3	174.6	0.4	1.7
LSD (.05)		2518.3	7.62	1.47	1.42	4.9	31.7	2.4	1.0
C.V. (%)		20.7	21.69	6.09	4.68	4.4	13.0	406.7	44.1
F value		6.6**	5.11**	6.58**	7.49**	2.1**	4.2**	1.1NS	2.8**

NOTES: See test 1305 under non-diseased conditions. At harvest in mid-November, counts for SBCN for N465-9m and 4842 were 0.0 and 45, respectively.

TEST 405. RETEST OF HYBRIDS FROM 2004, SPENCE, CA, 2005

12 entries x 8 reps., RCB
1-row plots, 22 ft. long

Planted: April 19, 2005
Harvested: October 4, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	PM Score
%S check								
Z210H50	C790-15CMS x Z10 (Polish %S)	15254	39.81	19.15	23.04	83.2	143	3.8
Hybrids with increases of FS								
R381-22H50	C790-15CMS x R181-22, (C81-22)	15234	43.13	17.70	21.56	82.1	150	3.0
R380-21H50	C790-15CMS x R180-21	15910	44.72	17.79	21.64	82.2	142	3.5
Y368-8H50	C790-15CMS x Y168-8	14877	41.70	17.81	21.20	84.0	137	2.3
Y390-40H50	C790-15CMS x Y190-40	16079	44.44	18.10	21.98	82.4	164	3.9
Y390-43H50	C790-15CMS x Y190-43	16428	45.05	18.24	21.90	83.3	161	3.9
Hybrids with increases of S_1's								
4933-14H50	C790-15CMS x 2933-14	15056	41.57	18.11	21.71	83.4	144	3.1
3931-56H50	C790-15CMS x 1931-56	16252	45.50	17.86	21.64	82.6	155	2.4
Z331-14H50	C790-15CMS x Z131-14	15729	42.38	18.56	22.51	82.5	143	3.5
3941-107H50	C790-15CMS x 1941-107	15632	43.33	18.04	21.50	83.9	151	3.6
3933-118H50	C790-15CMS x 1933-118	16168	46.05	17.56	21.21	82.8	134	4.8
CR311-88H50	C790-15CMS x CR111-88	16559	47.31	17.50	21.16	82.7	151	4.5
Mean		15764.9	43.75	18.04	21.75	82.9	147.8	3.5
LSD (.05)		1156.1	3.10	0.42	0.55	1.6	15.1	0.7
C.V.(%)		7.4	7.11	2.31	2.54	1.9	10.3	20.8
F value		1.9NS	3.84**	9.76**	8.04**	1.4NS	2.9**	8.4**

TEST 705. VIRUS YELLOWS EVALUATION OF EXPERIMENTAL HYBRIDS, NOT INOCULATED, SALINAS, CA, 2005

24 entries x 8 reps, RCB(e)
1-row plots, 22 ft. long

Planted: April 19, 2005
Harvested: September 29, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/100' No.	PM Score
Checks								
Phoenix	9/12/03	13816	40.86	16.90	20.21	83.7	152	3.9
Beta 4430R	8/21/03	15659	44.39	17.66	21.05	83.9	148	2.3
Z210H50	C790-15CMS x Z010-Z017	14153	38.14	18.58	22.45	82.8	130	3.6
Y491H50	C790-15CMS x RZM Y391	13518	39.64	17.06	20.75	82.2	120	2.8
Parental Checks								
3942H50	C790-15CMS x RZM 2942	14275	42.12	17.00	21.17	80.2	135	2.4
Y190H50	C790-15CMS x RZM Y090	14336	41.55	17.25	21.20	81.4	110	3.0
CR411H50	C790-15CMS x RZM CR311	14094	41.66	16.91	20.56	82.3	130	3.0
Z425H50	C790-15CMS x RZM Z325	13715	39.45	17.38	21.41	81.2	143	3.0
4931H50	C790-15CMS x RZM 3931	14638	42.07	17.41	21.42	81.3	132	2.5
4941H50	C790-15CMS x RZM 3941	14514	42.58	17.06	20.36	83.8	136	2.6
Experimental Hybrids								
4951-210H50	C790-15CMS x 2951-210	14631	42.22	17.34	21.39	81.1	140	2.6
4952-202H50	C790-15CMS x 2952-202	16493	46.51	17.74	21.25	83.5	139	3.3
4952-205H50	C790-15CMS x 2952-205	15280	43.33	17.65	21.46	82.2	140	2.6
4952-212H50	C790-15CMS x 2952-212	13955	40.60	17.20	21.08	81.6	131	3.5
4952-222H50	C790-15CMS x 2952-222	14581	40.50	18.00	21.89	82.3	136	2.1
4953-209H50	C790-15CMS x 2953-209	14497	42.14	17.20	20.94	82.2	131	1.5
4953-215H50	C790-15CMS x 2953-215	13933	41.89	16.64	20.45	81.4	131	2.6
4953-217H50	C790-15CMS x 2953-217	15567	44.08	17.67	21.15	83.6	139	3.1
4954-204H50	C790-15CMS x 2954-204	14745	41.52	17.76	21.40	83.0	143	2.9
4954-207H50	C790-15CMS x 2954-207	16154	46.66	17.31	20.98	82.5	144	3.0

TEST 705. VIRUS YELLOWS EVALUATION OF EXPERIMENTAL HYBRIDS, NOT INOCULATED, SALINAS, CA, 2005 (cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	PM Score
Experimental Hybrids (cont.)								
4954-210H50	C790-15CMS x 2954-210	14327	39.60	18.10	22.09	81.9	137	2.8
4954-225H50	C790-15CMS x 2954-225	15588	44.95	17.34	20.94	82.8	138	2.6
4942-202H50	C790-15CMS x 2942-202	15200	43.76	17.38	21.09	82.5	141	2.6
4942-211H50	C790-15CMS x 2942-211	14797	42.68	17.34	21.23	81.7	139	2.1
Mean		14686.1	42.21	17.41	21.16	82.3	136.1	2.8
LSD (.05)		1107.9	3.06	0.62	0.70	2.3	13.6	0.8
C.V. (%)		7.7	7.35	3.63	3.37	2.8	10.1	28.5
F value		3.8**	3.77**	3.72**	4.20**	1.4NS	3.2**	3.4**

TEST 805. EVALUATION OF TOPCROSS HYBRIDS, SALINAS,CA, 2005

24 entries x 8 reps, RCB(e)
1-row plots, 22 ft. long

Planted: April 20, 2005
Harvested: September 29, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	PM Score
Checks								
Phoenix	9/12/03	14747	43.49	16.95	20.02	84.7	143	4.5
Beta 4430R	8/21/03	16833	49.23	17.10	20.10	85.1	147	2.5
Topcrosses with Y91								
Y491H50	C790-15CMS x Y391	14924	43.32	17.23	20.52	83.9	122	3.0
Y491H5	C833-5HO x Y391	15329	42.89	17.91	21.52	83.2	120	3.8
Y491H77	1833-5-8HO x Y391	15181	43.38	17.50	21.49	81.4	118	3.5
Y491H78	1833-5-11HO x Y391	14544	41.44	17.58	21.29	82.6	99	3.5
Y491H14	3869-24H5 x Y391	14361	41.57	17.29	20.81	83.1	130	4.3
Y491H15	3869-27H5 x Y391	14072	41.05	17.14	20.86	82.1	125	4.1
Y491H16	3869-30H5 x Y391	13702	39.66	17.29	20.90	82.7	124	4.0
Y491H67	3837-6HO x Y391	13541	38.71	17.50	21.51	81.4	121	4.1
Y491H75	03-FC123-31H5 x Y391	14177	40.26	17.61	21.52	81.9	128	4.0
Y491H76	03-FC1014-22H5 x Y391	14110	40.08	17.60	21.45	82.1	128	3.3
Y491H73	03-FC124HO x Y391	13260	39.96	16.61	20.26	82.0	122	3.8
Y491H74	03-FC1015HO x Y391	12874	36.41	17.69	21.85	81.0	116	3.8
Y491H42	3842HO (C842CMS) x Y391	14052	41.07	17.10	20.59	83.1	139	4.5
Y491H70	3869HO (C869CMS) x Y391	13539	40.61	16.67	20.15	82.8	135	4.0
Testcross hybrids with RKN resistance								
K402H5	C833-5HO x RKNR M6-2	14369	43.11	16.67	20.56	81.1	129	5.3
K403H5	C833-5HO x RKNR M1-3,-3a	15301	45.45	16.83	20.34	82.8	145	5.5
K404H5	C833-5HO x RKNR M1-4	15415	44.09	17.46	21.25	82.2	134	5.5
Testcross hybrids with selected progeny lines								
R480-6H5	C833-5HO x R280-6	15951	45.43	17.55	21.13	83.1	131	4.5
4941-20H5	C833-5HO x 2941-20	15161	43.93	17.25	21.34	80.8	130	4.3

TEST 805. EVALUATION OF TOPCROSS HYBRIDS, SALINAS,CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Soluble Solids	RJAP	Beets/ 100'	PM
		Lbs	Tons	%	%	%	No.	Score
Testcross hybrids with selected progeny lines (cont.)								
4933-14H5	C833-5HO x 2933-14	14722	41.44	17.73	21.57	82.2	130	4.8
Z431-18H5	C833-5HO x Z131-18	15319	43.08	17.79	21.90	81.2	145	3.9
P318-6H5	C833-5HO x P118-6, (CP08)	15290	44.44	17.21	21.34	80.7	129	5.4
Mean		14615.6	42.25	17.30	21.01	82.4	128.7	4.2
LSD (.05)		984.7	2.75	0.49	0.56	2.0	13.9	0.8
C.V. (%)		6.8	6.61	2.88	2.68	2.5	11.0	18.9
F value		6.7**	7.16**	4.35**	8.35**	2.6**	4.7**	7.6**

TEST 905. HYBRIDS WITH COMBINED RESISTANCE TO SBCN & RHIZOMANIA FROM VARIOUS SOURCES, SALINAS, CA, 2005

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: April 20, 2005
Harvested: September 28, 2005

Variety	Resistance Rz	NR1	NR2	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	PM Score
Checks											
Beta 4430R	√			RZM resist. ck, 8/21/03	15662	46.13	16.98	19.81	85.7	145	2.6
Phoenix	√			Comm. check, 9/12/03	14014	42.25	16.56	19.51	84.9	138	5.1
Roberta				Susc. check, 2/25/04	15270	46.33	16.42	19.63	83.7	136	3.6
US H11				Susc. check, 10/4/02	12218	38.59	15.80	19.15	82.6	145	7.0
Syngenta hybrids											
Hil-1	√	√		8/04	14264	41.67	17.10	20.74	82.4	139	3.9
Hil-2	√	√		8/04	13112	39.73	16.49	20.10	82.0	135	4.0
Hil-3		√		8/04	15205	48.07	15.80	18.99	83.3	145	4.0
Holly hybrids											
HXN1	√	√		4/05	13049	39.84	16.38	19.88	82.4	122	5.0
HXN2	√		√	4/05	13777	39.55	17.40	21.14	82.3	143	7.0
Betaseed hybrids											
2VK0305	√	√		2/15/05	15440	47.77	16.14	19.95	80.9	139	2.5
0VK6280		√		2/15/05	14139	44.59	15.86	19.25	82.4	141	2.9
2AP0852	√		√	2/15/05	13466	40.61	16.55	20.16	82.1	159	6.0
2EN5066			√	2/15/05	13513	42.81	15.85	19.20	82.6	147	5.9
USDA breeding lines											
N412(Sp)	√		√	N212-#(C),N312aa x A,(CN12)	14070	42.81	16.44	19.85	82.8	131	2.0
N472(Sp)	√		√	N272-#(C),N372aa x A,(CN72)	13337	41.08	16.24	19.66	82.6	127	2.5
Y475	√		√	RZM-ER-% Y275	12737	39.10	16.24	20.15	80.6	137	3.8
USDA experimental hybrids											
N412H5	√		√	C833-5HO x N212-#(C),N312(CN12)	15117	43.37	17.42	20.91	83.3	130	3.1
N472H5	√		√	C833-5HO x N272-#(C),N372(CN72)	14946	44.25	16.90	20.25	83.5	134	3.6

TEST 905. HYBRIDS WITH COMBINED RESISTANCE TO SBCN & RHIZOMANIA FROM VARIOUS SOURCES, SALINAS, CA, 2005 (cont.)

Variety	Resistance Rz	NR1	NR2	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/100' No.	PM Score
USDA experimental hybrids (cont.)											
1927-4H5	√		√	C833-5HO x RZM 9927-4,(C927-4)	14541	42.64	17.02	20.90	81.5	119	4.5
4927-202H50	√		√	C790-15CMS x 2927-4-202 (CN927-202)	14897	43.59	17.11	20.75	82.5	141	3.8
HXN3	√		√	Holly Hybrids, 3/05	13089	39.50	16.58	19.91	83.3	129	6.1
N412-202H5	√		√	C833-5HO x N212-202	15391	44.99	17.15	21.19	81.0	128	3.8
N472-233H5	√		√	C833-5HO x N272-233	15227	45.69	16.65	20.20	82.4	124	4.8
4926-11-3-22H5	√		√	C833-5HO x 2926-11-3-22 (CN926-11-3-22)	14029	39.76	17.64	21.48	82.2	125	3.5
Mean					14187.9	42.70	16.61	20.12	82.6	135.8	4.2
LSD (.05)					1168.2	2.77	0.70	0.78	2.3	12.2	0.8
C.V. (%)					8.4	6.58	4.28	3.93	2.8	9.1	18.6
F value					5.5**	8.15**	4.55**	6.12**	2.0*	4.7**	25.7**

NOTES: See Tests B505 & B205 from Imperial Valley and Tests 4805, 1005, and 4705 from Salinas.

Test 905 was grown under essentially disease free conditions. Test area was fumigated with methylbromide/ chloropricrin in October 2003 and strawberries grown in 2003-2004. Powdery mildew was controlled until late in the season.

Rz = Holly (*Rz1*) or other sources of resistance to rhizomania.
NR1 = *Beta procumbens* source of nematode resistance.
NR2 = Possible nematode resistance from other sources.

Lines N412(CN12), N472(CN72), Y475, C927-4, 2927-4-202 (CN927-202), N212-202, and N272-233 were chosen for testing because of their performance in tests in Imperial Valley under the pressure of SBCN, rhizomania, and high temperature. They may or may not have resistance to SBCN.

Test 905 performances were used to estimate the combined effects of rhizomania/SBCN on the campaign entries in Test 4805.

SBCN counts/100g of soil were 0.0.

TEST 1005. EVALUATION OF SBCN/RHIZOMANIA RESISTANT PROGENY HYBRIDS, SALINAS, CA, 2005

48 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: April 20, 2005
Harvested: September 27, 2005

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Soluble Solids	RJAP	Beets/ 100'	PM
		Lbs	Tons	%	%	%	No.	Score
Checks								
Acclaim	3/15/05 Holly Hybrids	12383	40.66	15.28	18.49	82.7	136	3.9
Beta 4430R	8-21-03 Betaseed	15202	45.15	16.84	19.84	84.9	144	2.6
Phoenix	9-12-03 Holly Hybrids	13730	42.02	16.29	19.42	83.9	132	3.5
Beta 4001R	8-21-03 Betaseed	15110	43.23	17.44	20.84	83.7	136	1.1
Angelina	2-25-04	14228	40.73	17.45	20.65	84.4	132	6.0
US H11	susc. check	12260	38.71	15.81	19.00	83.1	138	6.0
Roberta	2-25-04	15043	45.29	16.56	20.00	82.9	126	3.1
SBCNR hybrids from seed companies								
2VK0305	Betaseed 2/15/05	14262	43.44	16.48	20.05	82.2	134	2.6
OVK6280	Betaseed 2/15/05	13542	42.78	15.75	18.90	83.3	141	2.4
2AP0852	Betaseed 2/15/05	12476	37.87	16.51	19.94	82.8	133	5.3
2EN5066	Betaseed 2/15/05	13030	40.46	16.10	19.33	83.4	140	5.9
HXN1	9/7/04 Holly Hybrids	12642	38.14	16.58	20.00	82.9	129	4.5
HXN2	9/7/04 Holly Hybrids	12099	35.07	17.27	21.06	82.0	141	5.9
Hil-1	8/04 Syngenta	13712	40.35	16.99	20.55	82.7	136	3.4
Hil-2	8/04 Syngenta	12917	39.89	16.19	19.69	82.3	130	3.3
Hil-3	8/04 Syngenta	14027	44.29	15.81	18.42	85.8	141	2.8
USDA breeding lines and their hybrids								
N412(Sp)	N212-#(C), N312aa x A, (CN12)	13498	40.66	16.61	20.06	82.9	131	1.8
N472(Sp)	N272-#(C), N372aa x A, (CN72)	14222	42.53	16.73	20.44	81.9	139	2.4
Y475	RZM-ER-% Y275	11803	34.72	17.00	20.52	82.9	136	3.6
Y475H5	C833-5HO x RZM-ER-% Y275	14085	40.61	17.35	21.39	81.2	145	3.5
Y477H5	C833-5HO x RZM-ER-% Y277	13416	38.97	17.21	21.04	81.9	137	5.3
N412H5	C833-5HO x N212-#(C),N312,(CN12)	13940	40.11	17.36	21.24	81.8	133	3.3
N472H5	C833-5HO x N272-#(C),N372,(CN72)	14573	42.78	17.02	20.74	82.1	140	3.5

TEST 1005. EVALUATION OF SBCN/RHIZOMANIA RESISTANT PROGENY HYBRIDS, SALINAS, CA, 2005 (cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/100' No.	PM Score
USDA breeding lines and their hybrids (cont.)								
1927-4H5	C833-5HO x RZM 9927-4 (C927-4)	13462	39.54	17.02	20.77	82.0	124	5.3
P431H5	C833-5HO x RZM,CTR R278,P230,P207/8	14620	42.33	17.29	21.05	82.1	145	2.3
Y467-21H50	C790-15CMS x RZM Y267-21	14108	41.12	17.19	20.88	82.3	151	3.0
Y471-14H50	C790-15CMS x RZM Y271-14	14534	42.17	17.25	21.15	81.6	137	4.8
R443-14H50	C790-15CMS x RZM R243-14	14940	44.02	16.99	20.38	83.4	144	3.1
N412H50	C790-15CMS x N212-#(C), N312, (CN12)	14142	42.02	16.84	20.34	82.8	137	3.1
N472H50	C790-15CMS x N272-#(C), N372, (CN72)	14301	43.13	16.60	19.95	83.2	145	3.5
4927-202H50	C790-15CMS x 2927-4-202 (CN927-202)	16172	46.81	17.27	21.05	82.1	141	3.9
N424H5	C833-5HO x RZM N324-#(C)(g) (*B.pro*)	13800	40.21	17.17	21.06	81.5	144	4.8
Hybrids with progeny lines selected for I.V. performance								
N412-6H5	C833-5HO x N212-6	12111	34.06	17.73	21.42	82.7	79	3.0
N412-11H5	C833-5HO x N212-11	14888	42.26	17.61	21.65	81.4	73	3.1
N412-13H5	C833-5HO x N212-13 (susc. ck.)	15293	44.54	17.19	20.86	82.4	124	1.1
N412-202H5	C833-5HO x N212-202	15124	43.79	17.29	21.20	81.6	124	3.9
N412-203H5	C833-5HO x N212-203	15383	45.30	16.99	20.57	82.6	133	1.0
N412-205H5	C833-5HO x N212-205	13614	39.05	17.45	21.34	81.8	130	5.0
N472-230H5	C833-5HO x N272-230	14478	43.64	16.59	20.00	83.0	126	4.3
N472-231H5	C833-5HO x N272-231	12060	36.01	16.75	21.26	78.8	62	3.3
N472-233H5	C833-5HO x N272-233	14542	43.27	16.83	20.34	82.7	123	4.5
4926-11-3-22H5	C833-5HO x 2926-11-3-22 (CN926-11-3-22)	14064	40.33	17.41	21.29	81.8	137	3.9

TEST 1005. EVALUATION OF SBCN/RHIZOMANIA RESISTANT PROGENY HYBRIDS, SALINAS, CA, 2005 (cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	PM Score
Hybrids with progeny lines selected for I.V. performance (cont.)								
4926-11-1-3H5	C833-5HO x 2926-11-1-3	14696	41.77	17.60	21.60	81.5	124	3.5
4926-11-7-61H5	C833-5HO x 2926-11-7-61	13219	36.68	18.04	22.25	81.1	136	4.5
4926-11-10-91H5	C833-5HO x 2926-11-10-91	13322	37.64	17.71	21.65	81.8	127	3.9
Topcross hybrids with Bp-mm females for SBCNR								
Y491H5	C833-5HO x Y391	13490	38.31	17.63	21.29	82.8	109	3.8
HXN3	Holly Hybrids, 4/05	12773	38.85	16.46	19.83	83.0	129	6.1
Y491H99	N369HO(g) x Y391 (*B.pro*)	12714	37.95	16.76	20.05	83.7	119	4.6
Mean		13834.4	40.90	16.92	20.52	82.5	130.3	3.7
LSD (.05)		1375.2	3.77	0.64	0.75	2.1	18.0	0.9
C.V. (%)		10.1	9.35	3.83	3.70	2.6	14.1	24.9
F value		4.3**	4.74**	6.37**	10.02**	2.1**	7.2**	15.3**

NOTES: See Tests B205 & B405 from Imperial Valley and Test 4705 fro Salinas.

Test 1005 was grown under essentially disease free conditions, following methylbromide/chloropricin fumigation in October 2003. Powdery mildew was controlled until late in the season.

See Test 905 for sources of resistance.

N412(Sp) = CN12 has SBCN resistance from WB242.
N472(Sp) = CN72 has SBCN resistance from *B.vulgaris maritima*.
Y475 & Y477 may have SBCN resistance from C51.
1927-4 = C927-4 may have SBCN resistance for C51.
P431CT = CP09CT may have SBCN resistance form C51 and/or WB242.
Y467-21, Y471-14, R443-14 may have SBCN resistance from C51.

TEST 1005. EVALUATION OF SBCN/RHIZOMANIA RESISTANT PROGENY HYBRIDS, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield			Soluble		Beets/	
		Sugar	Beets	Sucrose	Solids	RJAP	100'	PM
		Lbs	Tons	%	%	%	No.	Score

NOTES: (cont.)

4927-202 = CN927-202 was selected from C927-4.
N424 has SBCN resistance from *B.procumbens*.
N212-#s were selected from CN12.
N272-#s were selected from CN72.
4926-11-3-22 = CN926-11-3-22 and has SBCN resistance from C51.
N369HO(g) segregates for SBCN resistance from *B.procumbens*.

Test 1005 performances were used to estimate the relative combined effects of rhizomania/SBCN on the companion entries in Test 4705.

TEST 1105. EVALUATION OF HYBRIDS WITH SELECTED PROGENY LINE POLLINATORS, SALINAS, CA, 2005

48 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: April 20, 2005
Harvested: September 26, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/100' No.	PM Score
Checks								
Beta 4001R	8/21/03 Betaseed	14565	42.33	17.21	20.86	82.5	143	1.4
Phoenix	9/12/03 Holly Hybrids	13904	42.43	16.35	19.67	83.1	148	4.8
Acclaim	3/15/05 Holly Hybrids	14149	44.09	16.02	19.02	84.3	145	4.5
Beta 4430R	8/21/03 Betaseed	15126	44.74	16.86	20.24	83.5	150	2.6
Populations hybrids								
4931H50	C790-15CMS x 3931 (C931)	14090	41.52	16.99	20.66	82.2	146	3.1
4941H50	C790-15CMS x 3941 (C941)	13701	41.22	16.59	20.35	81.5	127	3.3
CR411H50	C790-15CMS x CR311 (CR11)	12717	38.38	16.58	19.75	84.0	138	3.5
Z425H50	C790-15CMS x Z325 (CZ25/2)	12871	38.35	16.77	20.27	82.8	143	3.4
4943H50	C790-15CMS x 3943	12471	37.00	16.86	20.71	81.4	131	3.1
N412H50	C790-15CMS x N212-#(C),N312,(CN12)	13969	41.92	16.66	20.34	81.9	138	2.4
N472H50	C790-15CMS x N272-#(C),N372,(CN72)	13917	41.97	16.61	20.26	82.0	134	3.5
P318-6H50	C790-15CMS x P118-6, (CP08)	13391	40.16	16.67	20.42	81.7	134	3.9
P207/8H50	C790-15CMS x P007/8, (CP07)	13503	40.38	16.75	20.67	81.0	141	2.9
04-FC1028H5	C833-5HO x RZM-% FC20021028	13347	38.84	17.17	20.89	82.2	135	3.9
04-FC1037H5	C833-5HO x RZM-% FC20021037	13269	38.88	17.09	20.76	82.4	128	4.8
04-FC1038H5	C833-5HO x RZM-% FC20021038	12237	35.71	17.15	21.02	81.6	105	5.0
Experimental hybrids and retests								
Y491H50	C790-15CMS x Y391	11883	35.32	16.79	20.66	81.3	120	2.9
R421H5	C833-5HO x RZM-ER-% R221	13891	41.08	16.91	20.66	81.9	135	4.0
R480-6H50	C790-15CMS x R280-6	13727	40.13	17.11	20.60	83.1	126	3.4
4941-20H50	C790-15CMS x 2941-20	13868	41.17	16.85	20.73	81.3	141	3.3
4933-14H50	C790-15CMS x 2933-14	12977	37.59	17.27	20.92	82.6	125	3.5
Z431-18H50	C790-15CMS x Z131-18	13095	39.06	16.76	20.59	81.5	136	2.6
Z425-214H50	C790-15CMS x Z225-214	13913	39.93	17.42	21.24	82.1	141	4.5

TEST 1105. EVALUATION OF HYBRIDS WITH SELECTED PROGENY LINE POLLINATORS, SALINAS, CA, 2005 (cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/100' No.	PM Score
Experimental hybrids and retests (cont.)								
4929-221H50	C790-15CMS x 2929-112-221	13403	38.55	17.38	21.27	81.7	145	3.4
4929-227H50	C790-15CMS x 2929-112-227	13499	39.55	17.05	20.61	82.7	147	3.0
4930-229H50	C790-15CMS x 2930-35-229	13867	40.25	17.25	20.94	82.4	143	4.4
S_1 progeny lines from CR popns & lines								
CR410-231H50	C790-15CMS x CR210-14-2-231	12970	40.01	16.23	19.99	81.3	140	5.3
CR412-211H50	C790-15CMS x CR212-5-211	14097	40.97	17.21	20.92	82.3	144	3.8
CR412-5H50	C790-15CMS x CR212-5-211,-212-216,-218	13383	39.76	16.86	20.34	82.9	139	4.0
CR410-203H50	C790-15CMS x CR210-5-203	14410	41.80	17.23	20.85	82.7	136	3.4
S_1 progeny line from popn-924								
4924-203H50	C790-15CMS x 2924-203	14567	42.48	17.15	20.66	83.0	141	3.9
S_1 progeny lines from popn-942 (R576-89-18H18)								
4942-202H50	C790-15CMS x 2942-202	14451	43.08	16.79	20.52	81.8	146	3.1
4942-209H50	C790-15CMS x 2942-209	14565	42.53	17.13	20.59	83.2	137	2.1
4942-211H50	C790-15CMS x 2942-211	14547	41.67	17.45	21.33	81.9	153	2.1
S_1 progeny line from F_1 hybrid (CR11 x Y90)								
4951-210H50	C790-15CMS x 2951-210	14159	41.18	17.15	21.33	80.4	141	3.3
S_1 progeny line from F_1 hybrid (CZ25 x Y90)								
4952-202H50	C790-15CMs x 2952-202	13984	41.26	16.95	21.09	80.5	138	4.3
4952-205H50	C790-15CMs x 2952-205	13934	39.71	17.56	21.34	82.3	142	3.5
4952-212H50	C790-15CMS x 2952-212	13271	38.75	17.15	20.82	82.4	139	4.3
4952-222H50	C790-15CMS x 2952-222	13129	36.68	17.93	21.86	82.0	135	2.8
S_1 progeny lines from F_1 hybrid (C931 x Y90)								
4953-209H50	C790-15CMS x 2953-209	14957	43.23	17.30	20.95	82.6	145	1.5
4953-215H50	C790-15CMS x 2953-215	12194	37.41	16.26	20.13	80.8	140	3.0
4953-217H50	C790-15CMS x 2953-217	13646	40.52	16.89	20.91	80.8	131	4.5

TEST 1105. EVALUATION OF HYBRIDS WITH SELECTED PROGENY LINE POLLINATORS, SALINAS, CA, 2005 (cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	PM Score
S_1 progeny lines from F_1 hybrid (C941 x Y90)								
4954-204H50	C790-15CMS x 2954-204	13097	38.75	16.88	20.70	81.6	143	4.3
4954-207H50	C790-15CMS x 2954-207	14146	41.09	17.23	21.05	81.8	138	3.9
4954-210H50	C790-15CMS x 2954-210	13132	37.14	17.66	21.80	81.1	140	3.8
4954-213H50	C790-15CMS x 2954-213	13206	38.88	16.98	20.50	83.1	115	3.5
4954-225H50	C790-15CMS x 2954-225	15077	44.69	16.89	20.54	82.3	141	3.6
4954-231H50	C790-15CMS x 2954-231	13530	39.85	16.98	20.58	82.5	118	3.3
Mean		13662.5	40.25	16.98	20.69	82.12	137.2	3.5
LSD (.05)		1261.2	3.47	0.56	0.78	2.16	14.4	0.8
C.V. (%)		9.4	8.76	3.34	3.80	2.67	10.7	3.1
F value		2.6**	3.07**	3.35**	3.28**	1.20NS	3.3**	8.6**

NOTES: See Tests 205 & 305 for performance under virus yellows (BYV) conditions. See Tests 2405, 4505 & 4605 for performance under rhizomania.

The question I had was: Could the MM,S^f,A:aa populations C931, C941, CR11, and CZ25/2 be used in conjunction with MM,S^sS^s lines to create S_1 progenies for improvement of disease resistance and productivity, particularly %sugar? Genetic mole-sterile plants from the S^f,MM populations were randomly crossed to S^sS^s,MM lines to create F_1 population hybrids. These population hybrid plants (MM,S^f,Aa) were then selected randomly and selfed to produce S_1 progeny that would be MM,S^f,A:aa. The S_1 progeny were tested in the field at Salinas in separate trials under virus yellows (BChV) infected, rhizomania infected, and bolting induction conditions. Based upon these tests, about 5% of the S_1 progenies were selected and crossed to a common CMS tester (C790-15CMS) to produce testcross hybrids, evaluated in 2005 at Brawley and Salinas. The results are the data in Tests 1105, 4505, 4605, 2405, 1205, 205, 305, 605, 705, and B305.

Y90 = Y490 = Y390 = MM,S^sS^s line synthesized from selected full-sib progeny families.

TEST 305. VIRUS YELLOWS EVALUATION OF EXPERIMENTAL HYBRIDS, BYV INOCULATED, SALINAS, CA, 2005

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: April 19, 2005
Harvested: October 5, 2005
BYV Inoc: June 14, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Loss %	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/100' No.	PM Score	Virus Yellows 8/05	Virus Yellows 8/29	Virus Yellows 9/15	Virus Yellows Mean
Checks												
Phoenix	9/12/03	11135	19.4	33.21	16.75	84.1	159	7.1	4.5	3.4	4.6	4.2
Beta 4430R	8/21/03	13156	16.0	38.34	17.19	83.5	160	3.0	4.6	3.9	5.1	4.5
Z210H50	C790-15CMS x Z010-Z017	11252	20.5	32.30	17.41	82.4	151	5.5	4.1	3.3	4.9	4.1
Y491H50	C790-15CMS x RZM Y391	11493	15.0	34.62	16.60	80.7	120	1.9	2.6	2.0	3.0	2.5
Parental Checks												
3942H50	C790-15CMS x RZM 2942	12298	13.8	36.67	16.75	82.3	135	1.8	2.9	2.1	3.1	2.7
Y190H50	C790-15CMS x RZM Y090	11863	17.3	35.36	16.81	82.2	119	3.4	2.6	1.8	3.0	2.5
CR411H50	C790-15CMS x RZM CR311	11947	15.2	35.70	16.71	80.5	147	3.8	3.4	2.9	3.6	3.3
Z425H50	C790-15CMS x RZM Z325	11567	15.7	34.01	17.00	81.5	146	3.4	3.5	3.0	4.6	3.7
4931H50	C790-15CMS x RZM 3931	12971	11.4	37.84	17.13	81.2	143	2.1	2.6	2.6	4.0	3.1
4941H50	C790-15CMS x RZM 3941	12462	14.1	37.25	16.73	81.3	143	2.8	3.0	2.1	3.6	2.9
Experimental Hybrids												
4951-210H50	C790-15CMS x 2951-210	11743	19.7	34.97	16.76	80.3	137	1.4	2.8	2.3	3.5	2.8
4952-202H50	C790-15CMS x 2952-202	13604	17.5	39.65	17.16	81.1	147	3.8	2.5	2.1	2.9	2.5
4952-205H50	C790-15CMS x 2952-205	13124	14.1	38.55	17.01	81.0	141	2.5	3.0	2.5	3.3	2.9
4952-212H50	C790-15CMS x 2952-212	12752	8.6	37.19	17.15	82.0	148	3.9	2.6	1.6	2.4	2.2
4952-222H50	C790-15CMS x 2952-222	12832	12.0	36.83	17.42	81.1	148	1.3	3.0	2.3	3.1	2.8
4953-209H50	C790-15CMS x 2953-209	13340	8.0	39.55	16.86	81.6	148	0.9	2.4	1.9	2.8	2.3
4953-215H50	C790-15CMS x 2953-215	11601	16.7	35.32	16.41	81.2	151	2.1	2.6	1.8	2.8	2.4
4953-217H50	C790-15CMS x 2953-217	13078	16.0	39.11	16.70	80.9	144	2.6	1.5	1.0	1.4	1.3
4954-204H50	C790-15CMS x 2954-204	12457	15.5	36.42	17.10	82.2	134	3.0	3.3	2.8	3.4	3.1
4954-207H50	C790-15CMS x 2954-207	14056	13.0	41.93	16.76	81.5	152	4.0	2.8	1.9	2.8	2.5
4954-210H50	C790-15CMS x 2954-210	12238	14.6	34.51	17.73	80.8	133	1.6	2.5	1.3	2.6	2.1
4954-225H50	C790-15CMS x 2954-225	13604	12.7	39.45	17.23	81.7	147	1.9	2.5	1.5	2.9	2.3
4942-202H50	C790-15CMS x 2942-202	13493	11.2	39.60	17.02	82.7	143	1.5	2.5	1.6	3.3	2.5
4942-211H50	C790-15CMS x 2942-211	13055	11.8	38.15	17.11	81.2	151	1.0	2.9	2.4	3.3	2.8

TEST 305. VIRUS YELLOWS EVALUATION OF EXPERIMENTAL HYBRIDS, BYV INOCULATED, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Loss %	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/100' No.	PM Score	Virus Yellows 8/05	Virus Yellows 8/29	Virus Yellows 9/15	Virus Yellows Mean
Mean		12546.7		36.94	16.98	81.63	143.6	2.8	2.9	2.2	3.3	2.8
LSD (.05)		896.6		2.53	0.46	2.07	16.0	1.1	0.5	0.4	0.5	0.3
C.V. (%)		7.3		6.96	2.77	2.57	11.3	40.0	17.3	20.2	16.0	11.1
F value		6.7**		6.88**	3.28**	1.53NS	3.1**	14.2**	14.9**	19.0**	20.3**	42.3**

NOTES: Tests 305 and 705 are companion tests. Test 305 was inoculated June 14, 2005 with *Beet yellows virus* (BYV). %Loss is the relative sugar yield loss calculated from the corresponding means in each test. Inoculum was produced by H.-Y.Liu and J.L.Sears. A source of BYV was passed through *chenopodium captitatum* and from plants with severe vein clearing, transferred to sugarbeet plants used to produce viruliferous aphids for the field inoculation. BWYV and BChV could not be detected in the source plants or subsequently from plants inoculated in the field. Little natural VY infection appeared to occur.

Virus yellows foliar symptoms were scored on a scale of 0-9, where 9 = 90-100% of the mature leaf area yellowed. Scores were made on 8/05, 8/29, 9/15 by DP and JO.

At harvest, tests 305 and 705 showed moderate rhizomania.

Correlations within VY inoculated test 305

	SY	RY	%S	RJAP	% loss
BYV mean	-0.39NS	-0.44*	0.14NS	0.54**	0.41*
BYV 8/05	-0.41*	-0.46*	0.15NS	0.63**	0.42*
BYV 8/29	-0.33NS	-0.37NS	0.09NS	0.46*	0.38NS
BYV 9/15	-0.40NS	-0.45*	0.17NS	0.50*	0.39NS
% sugar	0.23NS	-0.03NS		0.08NS	-0.15NS
% loss	-0.61**	-0.59**	-0.15NS	0.11NS	

Correlations between corresponding tests

VY Inoc.	Non-inoculated test (Test 705) SY	RY	%S	RJAP
SY	0.83**	0.80**	0.14NS	0.24NS
RY	0.81**	0.87**	-0.07NS	0.22NS
% sugar	0.19NS	-0.18NS	0.81**	0.10NS
RJAP	-0.03NS	-0.02NS	-0.01NS	0.32NS
% loss	-0.07NS	-0.16NS	0.18NS	0.21NS

TEST 4505. RHIZOMANIA EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA, 2005

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: May 4, 2005
Harvested: October 18, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	PM Mean
Checks									
Acclaim	3/15/05	5870	18.22	16.17	18.96	85.3	140	7.2	2.5
Beta 4430R	8/21/03	8374	24.43	17.13	20.71	82.7	182	2.3	1.1
Z210H50	C790-15CMS x Z010-Z017	6140	17.81	17.20	20.67	83.2	169	6.1	4.6
Y491H50	C790-15CMS x RZM Y391	9070	26.74	16.96	20.71	81.9	173	3.7	2.4
Parental Checks									
3942H50	C790-15CMS x RZM 2942	8951	26.84	16.69	20.45	81.7	182	2.6	2.5
Y190H50	C790-15CMS x RZM Y090	8632	25.92	16.66	20.25	82.3	164	4.1	3.6
CR411H50	C790-15CMS x RZM CR311	9051	26.96	16.80	20.42	82.3	173	3.0	3.3
Z425H50	C790-15CMS x RZM Z325	8783	25.59	17.17	20.81	82.5	173	3.7	3.3
4931H50	C790-15CMS x RZM 3931	8339	24.82	16.80	20.34	82.7	181	6.7	2.3
4941H50	C790-15CMS x RZM 3941	8462	25.82	16.39	20.40	80.4	190	3.0	3.0
Experimental Hybrids									
4951-210H50	C790-15CMS x 2951-210	8968	26.78	16.74	20.50	81.7	186	4.1	1.6
4952-202H50	C790-15CMS x 2952-202	8560	25.33	16.91	20.46	82.7	189	6.7	2.6
4952-205H50	C790-15CMS x 2952-205	9851	29.06	16.95	21.02	80.6	180	3.1	2.5
4952-212H50	C790-15CMS x 2952-212	9207	27.21	16.95	20.54	82.6	189	3.8	4.0
4952-222H50	C790-15CMS x 2952-222	8387	24.29	17.26	20.79	83.1	187	7.4	3.8
4953-209H50	C790-15CMS x 2953-209	8695	25.97	16.74	20.48	81.8	186	10.4	1.0
4953-215H50	C790-15CMS x 2953-215	9762	29.08	16.74	20.15	83.1	193	3.4	2.5
4953-217H50	C790-15CMS x 2953-217	10488	31.03	16.90	20.64	81.9	186	5.7	3.3
4954-204H50	C790-15CMS x 2954-204	9727	27.83	17.48	20.85	83.8	184	3.3	3.6
4954-207H50	C790-15CMS x 2954-207	9993	29.86	16.74	20.05	83.5	194	3.8	3.3

TEST 4505. RHIZOMANIA EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	PM Mean
Experimental Hybrids (cont.)									
4954-210H50	C790-15CMS x 2954-210	8801	25.35	17.40	21.30	81.7	197	3.8	3.0
4954-225H50	C790-15CMS x 2954-225	9458	27.64	17.10	20.75	82.4	186	5.2	1.8
4942-202H50	C790-15CMS x 2942-202	8396	25.01	16.77	20.33	82.5	198	0.3	3.4
4942-211H50	C790-15CMS x 2942-211	8745	25.79	16.98	20.66	82.2	179	4.9	1.6
Mean		8779.5	25.97	16.90	20.51	82.5	181.7	4.5	2.8
LSD (.05)		822.4	2.34	0.45	0.57	2.2	18.0	5.1	0.7
C.V. (%)		9.5	9.13	2.68	2.80	2.7	10.0	115.5	25.9
F value		12.3**	12.72**	3.41**	4.51**	1.7*	3.6**	1.3NS	12.9**

TEST 4605. RHIZOMANIA EVALUATION OF HYBRIDS WITH SELECTED PROGENY LINE POLLINATORS, SALINAS,CA, 2005

48 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: May 4, 2005
Harvested: October 13, 2005

Variety	Description		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	PM Mean
Checks										
Beta 4001R	8/21/03	Betaseed	10930	31.98	17.10	20.61	83.0	197	3.0	0.3
Phoenix	9/12/03	Holly Hybrids	6538	20.39	16.02	19.24	83.4	143	3.4	2.8
Acclaim	3/15/05	Holly Hybrids	6767	21.44	15.89	18.70	84.9	144	1.0	2.6
Beta 4430R	8/21/03	Betaseed	8465	24.57	17.25	20.46	84.3	173	2.3	0.9
Populations hybrids										
4931H50	C790-15CMS x 3931 (C931)		9374	28.02	16.71	20.36	82.1	194	2.0	2.0
4941H50	C790-15CMS x 3941 (C941)		9416	28.59	16.48	19.73	83.5	180	1.9	2.3
CR411H50	C790-15CMS x CR311 (CR11)		9578	28.88	16.56	20.11	82.5	182	3.2	3.1
Z425H50	C790-15CMS x Z325 (CZ25)		8941	26.92	16.59	20.04	82.8	184	3.7	2.5
4943H50	C790-15CMS x 3943		8675	26.24	16.52	19.54	84.6	181	1.7	2.0
N412H50	C790-15CMS x N212-#(C),N312,(CN12)		9448	28.93	16.35	20.24	80.8	185	2.9	1.4
N472H50	C790-15CMS x N272-#(C),N372,(CN72)		10207	31.66	16.13	19.24	83.9	172	4.7	2.4
P318-6H50	C790-15CMS x P118-6, (CP08)		8704	26.69	16.27	19.65	82.9	180	3.1	3.0
P207/8H50	C790-15CMS x P007/8, (CP07)		9994	29.93	16.70	20.39	82.0	193	2.3	2.1
04-FC1028H5	C833-5HO x RZM-% FC20021028		9068	26.83	16.88	20.46	82.5	172	2.2	2.4
04-FC1037H5	C833-5HO x RZM-% FC20021037		9538	28.26	16.86	20.99	80.4	180	0.0	2.9
04-FC1038H5	C833-5HO x RZM-% FC20021038		9807	28.97	16.94	20.90	81.1	151	1.7	3.8
Experimental hybrids and retests										
Y491H50	C790-15CMS x Y391		8609	25.60	16.76	20.34	82.4	173	1.8	2.0
R421H5	C833-5HO x RZM-ER-% R221		10710	32.13	16.67	20.79	80.2	191	3.2	1.9
R480-6H50	C790-15CMS x R280-6		9534	28.11	16.96	20.32	83.5	182	3.0	2.5
4941-20H50	C790-15CMS x 2941-20		9468	28.50	16.59	19.81	83.7	183	6.2	2.0
4933-14H50	C790-15CMS x 2933-14		8762	26.06	16.75	20.05	83.6	183	2.4	1.5

TEST 4605. RHIZOMANIA EVALUATION OF HYBRIDS WITH SELECTED PROGENY LINE POLLINATORS, SALINAS,CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	PM Mean
Experimental hybrids and retests (cont.)									
Z431-18H50	C790-15CMS x Z131-18	8630	26.49	16.29	19.66	82.9	181	3.2	2.1
Z425-214H50	C790-15CMS x Z225-214	8036	24.06	16.70	19.94	83.8	192	5.8	3.8
4929-221H50	C790-15CMS x 2929-112-221	8724	25.71	16.94	20.79	81.5	193	2.6	2.0
4929-227H50	C790-15CMS x 2929-112-227	9114	26.60	17.13	20.55	83.4	169	3.1	1.0
4930-229H50	C790-15CMS x 2930-35-229	9104	26.16	17.41	20.92	83.2	176	2.4	3.4
S_1 progeny lines from CR popns & lines									
CR410-231H50	C790-15CMS x CR210-14-2-231	8652	26.64	16.23	19.81	81.9	182	1.6	4.9
CR412-211H50	C790-15CMS x CR212-5-211	9843	29.41	16.71	19.90	84.0	195	2.3	3.0
CR412-5H50	C790-15CMS x CR212-5-211,-212-216,-218	9369	28.17	16.60	19.74	84.1	186	3.4	3.9
CR410-203H50	C790-15CMS x CR210-5-203	9022	26.79	16.81	20.76	81.1	187	1.4	3.1
S_1 progeny line from popn-924									
4924-203H50	C790-15CMS x 2924-203	8884	26.69	16.64	20.07	82.9	183	3.8	2.0
S_1 progeny lines from popn-942 (R576-89-18H18)									
4942-202H50	C790-15CMS x 2942-202	8774	26.98	16.24	19.44	83.6	177	1.6	1.3
4942-209H50	C790-15CMS x 2942-209	9046	27.35	16.51	20.02	82.5	190	2.9	1.3
4942-211H50	C790-15CMS x 2942-211	9235	27.36	16.83	19.84	84.8	180	2.7	0.9
S_1 progeny line from F_1 hybrid (CR11 x Y90)									
4951-210H50	C790-15CMS x 2951-210	9526	28.36	16.79	20.57	81.6	189	2.0	1.9
S_1 progeny line from F_1 hybrid (Z25 x Y90)									
4952-202H50	C790-15CMs x 2952-202	8795	26.26	16.75	20.09	83.4	190	7.0	2.5
4952-205H50	C790-15CMs x 2952-205	10341	30.50	16.94	20.49	82.7	186	3.3	2.6
4952-212H50	C790-15CMS x 2952-212	9295	27.59	16.85	20.45	82.4	183	0.6	4.0
4952-222H50	C790-15CMS x 2952-222	8686	25.44	17.06	20.60	82.8	178	3.1	3.6

TEST 4605. RHIZOMANIA EVALUATION OF HYBRIDS WITH SELECTED PROGENY LINE POLLINATORS, SALINAS,CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Soluble Solids	RJAP	Beets/ 100'	Root Rot	PM
		Lbs	Tons	%	%	%	No.	%	Mean
S_1 progeny lines from F_1 hybrid (931 x Y90)									
4953-209H50	C790-15CMS x 2953-209	9399	28.12	16.64	19.90	83.6	187	8.3	0.3
4953-215H50	C790-15CMS x 2953-215	8765	26.97	16.20	19.41	83.5	189	1.8	2.4
4953-217H50	C790-15CMS x 2953-217	10206	30.31	16.83	20.49	82.1	168	6.0	2.9
S_1 progeny lines from F_1 hybrid (941 x Y90)									
4954-204H50	C790-15CMS x 2954-204	9480	27.88	16.99	20.26	83.9	182	7.0	4.0
4954-207H50	C790-15CMS x 2954-207	9897	29.84	16.56	19.77	83.8	193	2.7	3.9
4954-210H50	C790-15CMS x 2954-210	8906	25.78	17.27	20.89	82.8	180	1.7	2.5
Roberta	2/25/04, susc. check	4834	16.39	14.74	17.64	83.6	164	3.4	2.1
4954-225H50	C790-15CMS x 2954-225	9608	29.07	16.52	19.77	83.6	190	3.3	2.0
4954-231H50	C790-15CMS x 2954-231	8616	26.21	16.42	19.79	83.1	141	3.9	2.4
Mean		9069.1	27.21	16.64	20.07	82.9	179.8	3.1	2.4
LSD (.05)		1064.8	3.07	0.46	0.58	2.2	19.3	4.6	0.9
C.V. (%)		11.9	11.45	2.81	2.95	2.6	10.9	151.3	36.1
F value		7.0**	6.32**	6.72**	8.80**	2.0**	3.6**	1.1NS	10.5**

TEST 4905. RETEST UNDER RHIZOMANIA OF HYBRIDS FROM 2004, SPENCE, CA 2005

12 entries x 8 reps., RCB
1-row plots, 22 ft. long

Planted: May 4, 2005
Harvested: October 20, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %	PM Mean
%S check									
Z210H50	C790-15CMS x Z10 (Polish %S)	5620	17.08	16.46	19.89	82.8	178	3.9	4.3
Hybrids with increases of FS									
R381-22H50	C790-15CMS x R181-22, (C81-22)	9067	26.88	16.89	20.44	82.6	185	1.8	2.1
R380-21H50	C790-15CMS x R180-21	9336	27.55	16.95	20.70	81.9	186	0.0	2.6
Y368-8H50	C790-15CMS x Y168-8	9046	26.60	17.00	20.20	84.2	184	0.7	2.1
Y390-40H50	C790-15CMS x Y190-40	8609	25.21	17.06	20.80	82.1	198	2.3	2.3
Y390-43H50	C790-15CMS x Y190-43	8556	25.71	16.59	20.56	80.7	183	0.6	1.6
Hybrids with increases of S_1's									
4933-14H50	C790-15CMS x 2933-14	8700	25.91	16.77	20.40	82.2	180	0.6	1.3
3931-56H50	C790-15CMS x 1931-56	10049	30.51	16.45	19.67	83.6	184	1.6	1.3
Z331-14H50	C790-15CMS x Z131-14	8567	24.78	17.27	20.70	83.5	194	0.3	2.5
3941-107H50	C790-15CMS x 1941-107	9391	28.77	16.35	19.70	83.0	187	0.7	2.6
3933-118H50	C790-15CMS x 1933-118	9662	28.91	16.69	19.80	84.3	172	0.7	3.8
CR311-88H50	C790-15CMS x CR111-88	8956	27.21	16.49	19.82	83.2	182	1.5	3.6
Mean		8796.6	26.26	16.75	20.22	82.8	184.3	1.2	2.5
LSD (.05)		946.2	2.63	0.59	0.53	2.3	20.5	2.6	0.8
C.V. (%)		10.8	10.08	3.52	2.65	2.8	11.2	215.4	30.2
F value		10.8**	12.72**	1.94NS	5.09**	1.6NS	0.9NS	1.3NS	13.0**

TEST 5005. RHIZOMANIA EVALUATION OF TOPCROSS HYBRIDS, SALINAS, CA, 2005

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: May 4, 2005
Harvested: October 20, 2005

Variety	Description		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %
Checks									
Phoenix	9/12/03		7083	22.85	15.40	18.52	83.1	132	14.7
Beta 4430R	8/21/03		8841	26.40	16.80	19.96	84.2	153	17.7
Topcrosses with Y91									
Y491H50	C790-15CMS	x Y391	7358	22.19	16.55	19.84	83.5	135	16.3
Y491H5	C833-5HO	x Y391	9641	28.16	17.11	20.46	83.7	143	7.3
Y491H77	1833-5-8HO	x Y391	9005	26.41	17.04	20.83	81.8	149	7.5
Y491H78	1833-5-11HO	x Y391	8943	26.34	16.96	20.71	81.9	136	5.9
Y491H14	3869-24H5	x Y391	8079	25.21	16.01	19.36	82.6	140	7.8
Y491H15	3869-27H5	x Y391	8607	25.93	16.59	19.91	83.3	160	11.3
Y491H16	3869-30H5	x Y391	9128	26.66	17.14	20.59	83.2	164	7.4
Y491H67	3837-6HO	x Y391	8261	25.63	16.13	19.69	81.9	134	5.4
Y491H75	03-FC123-31H5	x Y391	8635	25.74	16.76	20.07	83.6	143	12.8
Y491H76	03-FC1014-22H5	x Y391	8949	25.88	17.25	21.05	82.0	155	4.2
Y491H73	03-FC124HO	x Y391	8342	26.53	15.70	18.76	83.7	145	5.3
Y491H74	03-FC1015HO	x Y391	8215	24.17	16.96	20.56	82.5	161	9.8
Y491H42	3842HO (C842CMS)	x Y391	7659	23.59	16.23	19.89	81.6	159	9.3
Y491H70	3869HO (C869CMS)	x Y391	8633	27.51	15.66	19.04	82.3	164	6.3
Testcross hybrids with RKN resistance									
K402H5	C833-5HO x RKNR M6-2		8046	24.97	16.10	19.45	82.8	145	14.3
K403H5	C833-5HO x RKNR M1-3,-3a		9119	28.22	16.10	19.26	83.6	176	14.0
K404H5	C833-5HO x RKNR M1-4		8993	27.19	16.55	19.71	84.0	149	12.9

TEST 5005. RHIZOMANIA EVALUATION OF TOPCROSS HYBRIDS, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	RJAP %	Beets/ 100' No.	Root Rot %
Testcross hybrids with selected progeny lines								
R480-6H5	C833-5HO x R280-6	8384	24.69	16.90	20.23	83.6	143	11.0
4941-20H5	C833-5HO x 2941-20	9458	28.55	16.55	19.90	83.2	155	16.3
4933-14H5	C833-5HO x 2933-14	7525	22.39	16.96	20.55	82.5	162	8.9
Z431-18H5	C833-5HO x Z131-18	8801	25.63	17.17	21.02	81.7	149	9.5
P318-6H5	C833-5HO x P118-6, (CP08)	8871	26.78	16.56	20.35	81.4	155	5.8
Mean		8524.0	25.73	16.55	19.99	82.8	150.3	10.1
LSD (.05)		1169.5	3.34	0.61	0.71	1.9	18.0	7.8
C.V. (%)		13.9	13.19	3.73	3.59	2.3	12.1	78.7
F value		2.4*	2.12*	5.79**	7.29**	1.5NS	3.0**	2.0*

TEST 4705. PERFORMANCE UNDER RHIZOMANIA/SBCN OF SBCN/RHIZOMANIA RESISTANT PROGENY HYBRIDS, SALINAS, CA, 2005

48 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: May 4, 2005
Harvested: October 19, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Relative SY(%)	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/ 100' No.	Foliar Color Score	PM Score	Root Rot %
Checks										
Acclaim	3/15/05 Holly Hybrids	7407	59.8	22.97	16.14	85.1	128	1.8	2.5	1.1
Beta 4430R	8-21-03 Betaseed	10144	66.7	29.43	17.23	83.2	175	1.5	1.4	1.4
Phoenix	9-12-03 Holly Hybrids	7569	55.1	23.02	16.40	82.1	135	1.4	2.6	7.7
Beta 4001R	8-21-03 Betaseed	12075	79.9	35.01	17.25	83.0	180	1.5	1.1	2.8
Angelina	2-25-04	10835	76.2	31.40	17.30	81.6	168	1.3	5.0	1.1
US H11	susc. check	5560	45.4	18.67	14.93	82.4	186	2.8	5.0	1.7
Roberta	2-25-04	5165	34.3	16.71	15.36	82.9	161	3.5	1.4	6.1
SBCNR hybrids from seed companies										
2VK0305	Betaseed, 2/18/05	10883	76.3	33.03	16.49	82.8	144	1.3	1.6	5.1
OVK6280	Betaseed, 2/18/05	4950	36.6	16.21	15.25	82.2	146	3.3	1.4	4.3
2AP0852	Betaseed, 2/18/05	10416	83.5	30.44	17.11	82.4	173	1.4	4.5	3.8
2EN5066	Betaseed, 2/18/05	6972	53.5	24.18	14.60	82.3	197	2.4	5.1	10.9
HXN1	Holly Hybrids, 4/05	10656	84.3	31.94	16.71	84.2	160	1.3	3.4	1.2
HXN2	Holly Hybrids, 4/05	9778	80.8	28.69	17.08	82.1	185	1.0	5.0	0.3
Hil-1	8/04, Syngenta	9652	70.4	28.77	16.80	83.0	162	1.8	1.6	2.8
Hil-2	8/04, Syngenta	9422	72.9	29.46	15.99	79.9	132	1.3	1.8	0.9
Hil-3	8/04, Syngenta	5257	37.5	18.68	13.73	83.4	169	3.6	1.1	1.0
USDA breeding lines and their hybrids										
N412(Sp)	N212-#(C), N312aa x A, (CN12)	10284	76.2	30.89	16.67	81.0	170	1.5	1.0	1.8
N472(Sp)	N272-#(C), N372aa x A, (CN72)	9954	70.0	30.73	16.21	79.6	182	1.8	1.4	4.0
Y475	RZM-ER-% Y275	10144	85.9	30.55	16.59	81.6	186	1.5	1.8	1.0
Y475H5	C833-5HO x RZM-ER-% Y275	11172	79.3	33.03	16.92	80.9	190	1.4	2.1	0.9
Y477H5	C833-5HO x RZM-ER-% Y277	11442	85.3	32.65	17.55	84.5	182	1.3	2.9	1.2

TEST 4705. PERFORMANCE UNDER RHIZOMANIA/SBCN OF SBCN/RHIZOMANIA RESISTANT PROGENY HYBRIDS, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Relative SY(%)	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/ 100' No.	Foliar Color Score	PM Score	Root Rot %
USDA breeding lines and their hybrids (cont.)										
N412H5	C833-5HO x N212-#(C), N312, (CN12)	11198	80.3	32.17	17.49	83.3	185	1.3	1.4	1.0
N472H5	C833-5HO x N272-#(C), N372, (CN72)	11226	77.0	32.94	17.04	81.6	188	1.1	1.6	1.8
1927-4H5	C833-5HO x RZM 9927-4 (C927-4)	11346	84.3	33.71	16.84	81.2	180	1.3	3.9	2.7
P431H5	C833-5HOxRZM,CTR R278,P230,P207/8,(CP09CT)	10778	73.7	31.12	17.33	81.6	184	1.3	1.1	1.5
Y467-21H50	C790-15CMS x RZM Y267-21	10335	73.3	31.70	16.40	83.6	201	1.9	1.1	4.1
Y471-14H50	C790-15CMS x RZM Y271-14	10612	73.0	31.51	16.84	82.5	178	1.8	2.8	1.1
R443-14H50	C790-15CMS x RZM R243-14	10924	73.1	32.41	16.86	85.0	197	1.1	1.6	1.7
N412H50	C790-15CMSxN212-#(C),N312,(CN12)	10042	71.0	30.05	16.73	82.6	190	2.1	1.3	3.1
N472H50	C790-15CMSxN272-#(C),N372,(CN72)	10423	72.9	31.86	16.40	81.8	190	2.0	2.6	2.3
4927-202H50	C79-15CMS x 2927-4-202,(CN927-202)	11736	72.6	34.40	17.05	81.3	191	1.4	2.4	7.5
N424H5	C833-5HO x RZM N324-#(C)(g)	9350	67.8	27.01	17.29	82.4	181	1.5	2.1	1.5
Hybrids with progeny lines selected for I.V. performance										
N412-6H5	C833-5HO x N212-6	11201	92.5	32.22	17.40	80.8	122	1.0	1.5	0.9
N412-11H5	C833-5HO x N212-11	10852	72.9	30.97	17.55	81.3	129	1.3	1.0	0.0
N412-13H5	C833-5HO x N212-13 (SBCN susc.ck.)	10155	66.4	30.46	16.73	82.3	192	1.1	1.0	4.8
N412-202H5	C833-5HO x N212-202	11497	76.0	33.24	17.29	83.0	166	1.3	2.1	2.0
N412-203H5	C833-5HO x N212-203	11733	76.3	35.37	16.59	81.0	176	1.0	1.0	4.7
N412-205H5	C833-5HO x N212-205	10443	76.7	29.04	18.00	82.1	169	1.4	1.8	2.5
N472-230H5	C833-5HO x N272-230	11832	81.7	35.80	16.51	80.8	164	1.3	2.9	2.8
N472-231H5	C833-5HO x N272-231	10503	87.1	30.55	17.23	81.0	66	1.0	1.9	3.6
N472-233H5	C833-5HO x N272-233	11447	78.7	34.37	16.65	81.6	157	1.0	1.9	1.6
4926-11-3-22H5	C833-5HO x 2926-11-3-22,(CN926-11-3-22)	10382	73.8	29.89	17.39	79.8	176	1.3	1.4	1.4
4926-11-1-3H5	C833-5HO x 2926-11-1-3	10934	74.4	31.94	17.06	82.2	187	1.4	1.3	5.8
4926-11-7-61H5	C833-5HO x 2926-11-7-61	10677	80.8	30.21	17.66	81.5	193	1.0	1.4	1.6
4926-11-10-91H5	C833-5HO x 2926-11-10-91	11384	85.5	32.22	17.69	81.2	187	1.3	1.5	2.8

TEST 4705. PERFORMANCE UNDER RHIZOMANIA/SBCN OF SBCN/RHIZOMANIA RESISTANT PROGENY HYBRIDS, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Relative SY (%)	Acre Yield Beets Tons	Sucrose %	RJAP %	Beets/100' No.	Foliar Color Score	PM Score	Root Rot %
Topcross hybrids with Bp-mm females for SBCNR										
Y491H5	C833-5HO x Y391	10473	77.6	30.16	17.40	83.1	156	1.6	1.9	1.9
HXN3	Holly Hybrids, 4/05	9322	73.0	27.56	16.85	83.6	162	1.6	3.6	5.6
Y491H99	N369HO(g) x Y391	10278	80.8	30.24	16.98	81.7	166	1.3	2.8	2.0
Mean		10017.1		29.78	16.74	82.2	169.6	1.6	2.2	2.8
LSD (.05)		1069.6		3.27	0.67	2.5	18.5	0.5	0.7	4.7
C.V. (%)		10.8		10.53	4.04	3.1	11.1	30.8	32.9	170.7
F value		21.8**		17.30**	11.90**	1.9**	13.9**	13.2**	21.9**	1.7**

NOTES: Relative SY values were calculated based on performance in tests 4705 versus 1005. Test 1005 was under essentially disease-free conditions. Test 4705 was infested with both rhizomania and SBCN. Planting and harvest dates for tests 1005 and 4705 were different as well. Comparison of the differences in varieties for relative SY are subject to experimental errors in both tests, as well as the differential reactions to rhizomania and SBCN.

See Tests 1005, 905, 4805, B505, and B405.

Foliar color was scored just prior to harvest on a scale of 1 to 5, where 5 = 100% yellowing associated with infection by rhizomania.

Root rot was caused by *Sclerotium rolfsii*. Rotted roots were weighed but not run thru the sugar lab.

See Tests B505, B405, 905, and 1005 for variety descriptions. N212-#s are S_1 lines from CN12. N272-#s are S_1 lines from CN72.. 2926-#s have SBCN resistance from C51, as does CN927-202.

Soil core samples were taken July 8, 2005 for Beta 4430R and Phoenix and composited by variety. Eggs+larvae counts/100g soil were 502 and 274, respectively. In late October before harvest, soil was sampled from Beta 4430R, Phoenix, 2AP0852, Hil-2, 4927-202H50, and 4926-11-3-22H5. Counts/100g soil were 95, 151, 48, 0, 331, and 107, respectively.

TEST 4805. HYBRIDS UNDER RHIZOMANIA/SBCN WITH COMBINED RESISTANCE TO SBCN & RHIZOMANIA FROM VARIOUS SOURCES, SALINAS, CA, 2005

24 entries x 8 reps., RCB(e)
2-row plots, 22 ft. long

Planted: May 4, 2005
Harvested: October 26, 2005

Variety	RZM Resistance			Description	Acre Yield			Sucrose	RJAP	Beets/ 100'	Foliar Color	PM	Root Rot
	Rz	NR1	NR2		Sugar Lbs	Relative SY(%)	Beets Tons	%	%	No.	Score	Score	%
Checks													
Beta 4430R	√			RZM resist ck,8/21/03	9236	59.0	26.64	17.36	81.9	166	1.8	1.4	4.4
Phoenix	√			Comm check, 9/12/03	9607	68.6	28.68	16.74	81.0	139	1.5	3.4	4.9
Roberta				Susc. check, 2/25/04	5465	35.8	17.83	15.31	81.4	167	3.3	1.8	3.7
US H11				Susc. check, 10/4/02	5018	41.1	16.62	15.14	79.0	170	3.2	5.4	2.3
Syngenta hybrids													
Hil-1	√	√		8/04	8914	62.5	26.62	16.76	81.0	165	1.6	1.6	2.3
Hil-2	√	√		8/04	8407	64.1	26.65	15.86	80.8	138	1.7	1.4	3.2
Hil-3		√		8/04	5850	38.5	20.22	14.52	79.6	153	3.5	1.1	4.5
Holly hybrids													
HXN1	√	√		4/05	9573	73.4	29.01	16.49	81.0	149	1.3	3.2	4.3
HXN2	√		√	4/05	8606	62.5	25.07	17.18	80.2	179	1.1	5.6	1.0
Betaseed hybrids													
2VK0305	√	√		2/18/05	10229	66.3	31.13	16.43	79.9	146	1.9	1.3	2.6
0VK6280		√		2/18/05	7055	49.9	22.81	15.54	81.0	139	3.3	1.4	4.4
2AP0852	√		√	2/18/05	9613	71.4	28.70	16.75	80.5	178	1.8	4.6	4.8
2EN5066			√	2/18/05	6754	50.0	22.24	15.22	81.7	190	2.4	5.6	3.4
USDA breeding lines													
N412(Sp)	√		√	N212-#(C),N312aa x A,(CN12)	9958	70.8	29.84	16.70	79.3	165	1.6	0.9	2.2
N472(Sp)	√		√	N272-#(C), N372aa x A,(CN72)	9254	69.4	28.01	16.51	78.4	167	1.7	1.3	3.5
Y475	√		√	RZM-ER-% Y275	9527	74.8	28.36	16.81	79.9	185	1.6	1.3	0.9
USDA experimental hybrids													
N412H5	√		√	C833-5HO x N212-#(C),N312	10203	67.5	30.39	16.80	78.8	167	1.1	1.5	3.2
N472H5	√		√	C833-5HO x N272-#(C),N372	10339	69.2	30.43	17.01	79.3	175	1.3	1.6	2.4

TEST 4805. HYBRIDS UNDER RHIZOMANIA/SBCN WITH COMBINED RESISTANCE TO SBCN & RHIZOMANIA FROM VARIOUS SOURCES, SALINAS, CA, 2005
(cont.)

Variety	RZM Resistance			Description	Acre Yield			Sucrose	RJAP	Beets/ 100'	Foliar Color	PM	Root Rot
	Rz	NR1	NR2		Sugar Lbs	Relative SY(%)	Beets Tons	%	%	No.	Score	Score	%
USDA experimental hybrids (cont.)													
1927-4H5	√		√	C833-5HO x RZM 9927-4,(C927-4)	9919	68.2	29.60	16.76	79.4	176	1.3	3.2	6.5
4927-202H50	√		√	C790-15CMSx2927-4-202	10837	72.7	32.01	16.94	80.1	183	1.3	2.3	8.3
HXN3	√		√	Holly Hybrids, 4/05	8503	65.0	26.38	16.13	80.2	157	1.7	4.1	3.0
N412-202H5	√		√	C833-5HO x N212-202	10546	68.5	31.40	16.81	79.3	172	1.1	2.2	3.6
N472-233H5	√		√	C833-5HO x N272-233	11041	72.5	32.52	16.98	79.0	134	1.3	2.6	0.4
4926-11-3-22H5	√		√	C833-5HO x 2926-11-1-3	10457	74.5	30.18	17.31	79.4	169	1.3	0.8	1.5
Mean					8954.6		27.14	16.42	80.1	163.6	1.8	2.5	3.4
LSD (.05)					1198.4		3.81	0.60	1.5	14.7	0.5	0.6	4.1
C.V. (%)					13.6		14.22	3.67	1.8	9.1	28.3	24.4	122.8
F value					16.0**		10.16**	12.64**	3.5**	9.2**	16.9**	53.3**	1.4NS

NOTES: Relative SY values were calculated based on performance in tests 4805 versus 905. Test 905 was under essentially disease-free conditions. Test 4805 was infested with both rhizomania and SBCN. Planting and harvest dates for tests 905 and 4805 were different as well. Comparison of the differences in varieties for relative SY are subject to experimental errors in both tests and the effects of both differential reactions to rhizomania and SBCN.

See Tests 905, 1005, 4705, B505, and B405.

Initial and harvest soil samples were taken to count SBCN populations for individual varieties. Processing of these samples is not yet complete. Prior to planting, the field area was sampled and nematode counts ranged from 255 to 490 eggs+larvae/100 grams soil for Test 4805.

Foliar color was scored just prior to harvest on a scale of 1 to 5, where 5 = 100% of yellowing associated with infection by rhizomania.

Root rot was caused by *Sclerotium rolfsii*. Rotted roots were weighed but not included in sugar sample.

TEST 4805. HYBRIDS UNDER RHIZOMANIA/SBCN WITH COMBINED RESISTANCE TO SBCN & RHIZOMANIA FROM VARIOUS SOURCES, SALINAS, CA, 2005
(cont.)

SUGARBEET CYST NEMATODE SOIL COUNTS

Variety	Resistance			Description	Cysts Full/Viable		No. Eggs & Larvae	
	Rz	NR1	NR2		7/08/05	10/05	7/08/05	10/05
Beta 4430R	√			RZM resist ck, 8/21/03	3	8	100	722
Phoenix	√			Commercial ck, 9/12/03	4	8	54	909
Hil-2	√	√		8/04	2	4	10	83
HXN1	√	√		9/7/04	2	5	30	850
HXN2	√		√	9/7/04	5	4	65	310
2VK0305	√	√		8/04	6	2	437	12
2AP0852	√		√	8/04	5	0	100	0
N412 (CN12)	√		√		6	4	401	180
N472 (CN72)	√		√		7	5	430	380
4927-202H50	√		√	C790-15CMS x CN927-202	2	5	310	155
4926-11-3-22H5	√		√	C833-5CMS x CN927-11-3-22	-	6	---	265

Varieties sampled on July 8, 2005 and again in late October 2005 at harvest.

NOTES: Counts for 100 grams soil. Soil cores taken to 12" deep, 8 cores/plot composited per plot, 3-4 inches from plants. Counts are for composites of all 8 reps within a variety. Therefore, ANOVA not possible.

TEST 4305. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA, 2005

72 entries x 8 reps (I-VIII), RCB
1-row plots, 22 ft. long

Planted: May 4, 2005
Harvested: November , 2005

Code No.	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI %	%R (0-3) %	%R (0-4) %	Foliar Color Score	Root Rot %	PM Score
Calif. Seed Comm. Coded Entries														
Rhz - 1	R510	Crystal	8985	24.25	18.55	22.56	36	37	4.3	30.2	66.9	1.5	0.4	1.0
- 2	4YK0901	Betaseed	8179	22.41	18.26	22.26	40	39	4.5	27.4	61.0	2.4	0.8	1.0
- 3	4YK0505	Betaseed	9243	25.10	18.50	22.47	40	39	4.5	22.0	57.9	2.0	2.1	0.6
- 4	HH-142	Holly Hyb	9088	25.43	17.84	22.04	39	40	3.9	43.7	73.3	1.1	0.0	2.8
- 5	Beta 4776R	Betaseed	10718	30.28	17.76	21.17	44	43	3.6	53.4	87.4	1.8	1.9	1.1
- 6	03HX308	Holly Hyb	9516	26.50	17.96	22.07	38	38	3.8	49.2	77.4	1.5	1.6	3.1
- 7	05HX508	Holly Hyb	8841	24.80	17.92	21.85	37	36	4.0	41.5	72.2	1.9	3.9	4.4
- 8	2GK6080	Betaseed	11006	30.26	18.26	22.10	43	44	3.5	58.2	81.3	1.5	1.1	1.1
- 9	4YK0802	Betaseed	10575	29.60	17.88	22.05	34	32	3.8	41.9	78.8	1.8	3.7	4.1
-10	4YK0504	Betaseed	10584	28.83	18.31	22.29	42	38	3.8	44.7	82.6	1.6	8.3	1.1
-11	4YK0903	Betaseed	10039	28.30	17.74	21.60	41	41	3.9	46.0	78.3	1.9	3.1	1.6
-12	4YK0502	Betaseed	7211	20.80	17.35	21.52	27	25	5.3	12.2	46.8	2.4	0.0	3.4
-13	852ON(2AP0852)	Betaseed	10916	31.33	17.39	21.11	39	40	3.7	50.9	81.5	1.9	3.2	3.5
-14	5YK0904N	Betaseed	10413	30.03	17.35	21.45	37	36	3.9	39.1	75.7	1.5	5.3	4.1
-15	04HX403	Holly Hyb	9113	24.98	18.22	22.24	33	34	3.9	37.1	78.5	1.9	1.6	1.1
-16	1GK0062	Betaseed	11039	31.78	17.39	21.31	39	39	3.5	58.7	89.2	2.1	0.6	1.3
-17	04HX405	Holly Hyb	9984	27.06	18.43	22.41	34	32	3.7	48.1	79.8	1.9	6.8	1.5
-18	05HX507	Holly Hyb	8725	23.86	18.29	22.01	43	42	3.7	53.7	84.1	2.4	4.0	4.8
-19	05HX517	Holly Hyb	9276	25.96	17.86	21.67	43	40	3.4	69.5	88.9	1.8	4.9	4.4
-20	05HX505	Holly Hyb	6842	20.40	16.81	20.63	33	30	4.4	30.9	59.7	2.4	4.3	1.6
-21	04HX413	Holly Hyb	9302	26.89	17.31	20.71	26	25	3.9	46.5	76.6	1.8	5.8	3.6
-22	03HX314	Holly Hyb	7516	21.92	17.16	20.71	37	34	4.3	33.6	65.0	2.8	4.1	1.3
-23	04HX401	Holly Hyb	7600	21.70	17.56	21.40	34	32	4.2	34.9	67.7	2.6	2.8	2.1
-24	04HX407	Holly Hyb	7035	20.90	17.00	21.00	30	27	4.3	36.2	69.8	2.9	1.6	3.8

TEST 4305. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA, 2005
(cont.)

Code No.	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI %	%R (0-3) %	%R (0-4) %	Foliar Color Score	Root Rot %	PM Score
Calif. Seed Comm. Coded Entries (cont.)														
Rhz -25	05HX501	Holly Hyb	9286	26.47	17.53	21.26	33	33	3.9	41.0	76.2	2.0	2.8	3.8
-26	05HX509	Holly Hyb	10016	27.66	18.16	22.24	41	41	3.9	44.0	74.6	2.1	3.4	4.3
-27	R444	Crystal	8081	22.27	18.14	22.16	27	23	4.8	16.7	53.6	3.3	3.6	1.9
-28	3YK0802	Betaseed	6877	19.21	17.90	22.21	38	35	4.5	20.9	59.9	2.3	0.8	0.6
-29	05HX515	Holly Hyb	9672	26.33	18.39	22.54	38	40	3.7	53.5	81.2	1.6	1.0	3.9
-30	05HX511	Holly Hyb	7395	22.14	16.79	20.74	37	33	4.2	30.6	68.0	2.3	2.8	3.5
-31	04HX404	Holly Hyb	5743	17.12	16.78	21.29	35	34	4.8	24.0	53.2	2.9	2.0	1.9
-32	Raptor	Holly Hyb	8104	23.47	17.31	20.93	38	36	4.3	25.5	59.9	2.5	6.9	2.1
-33	05HX504	Holly Hyb	9498	26.75	17.84	21.29	36	35	3.9	44.2	79.2	2.3	3.1	4.8
-34	3AT0439	Betaseed	9798	25.55	19.19	23.33	42	42	4.2	31.4	66.2	1.9	3.2	1.5
-35	4YK0902	Betaseed	8191	23.43	17.54	21.46	39	39	4.4	30.8	62.8	2.1	3.9	2.0
-36	1J5155	Betaseed	7591	21.17	17.96	21.59	39	37	5.1	16.1	43.3	2.6	3.0	0.9
-37	02HX219	Holly Hyb	8512	23.13	18.34	22.35	35	36	3.9	44.2	76.6	1.8	0.6	3.9
-38	05HX506	Holly Hyb	5770	16.75	17.31	21.42	33	31	4.7	22.0	51.6	2.9	1.4	1.9
-39	4YK0501	Betaseed	9765	26.99	18.11	22.26	30	31	3.9	31.9	82.4	1.5	0.4	1.1
-40	R441	Crystal	8077	22.76	17.74	21.58	35	34	4.9	17.2	50.5	2.1	0.0	1.0
-41	Phoenix	Holly Hyb	9841	27.75	17.73	21.36	33	29	4.0	42.1	75.1	2.3	1.8	3.8
-42	05HX516	Holly Hyb	10077	28.58	17.70	21.77	45	42	3.8	48.6	81.6	1.5	6.5	2.6
-43	5YK0906	Betaseed	3700	12.62	14.75	17.77	41	41	5.1	19.1	41.4	3.6	2.5	4.6
-44	4YK0801	Betaseed	10059	26.60	18.91	22.88	40	40	4.0	32.2	71.9	1.5	3.3	1.1
-45	05HX502	Holly Hyb	10556	28.64	18.46	22.40	39	40	3.6	55.0	83.3	1.6	1.3	1.3
-46	04HX408	Holly Hyb	8113	23.53	17.26	21.28	38	38	4.0	39.1	71.2	1.9	0.5	3.1
-47	05HX513	Holly Hyb	8348	22.89	18.25	22.69	36	37	4.0	44.8	74.7	1.4	3.2	3.4
-48	1GK7429	Betaseed	9742	29.38	16.63	20.33	36	35	4.1	47.3	69.1	1.6	1.8	1.5

TEST 4305. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA, 2005
(cont.)

Code No.	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI %	%R (0-3) %	%R (0-4) %	Foliar Color Score	Root Rot %	PM Score
Calif. Seed Comm. Coded Entries (cont.)														
Rhz -49	04HX417	Holly Hyb	8804	24.57	17.94	21.99	35	33	3.6	49.3	86.9	1.4	1.3	4.0
-50	05HX518	Holly Hyb	8710	24.49	17.79	21.59	39	36	3.6	55.7	85.4	1.8	3.2	3.6
-51	05HX519	Holly Hyb	9737	26.11	18.64	22.36	43	41	3.5	62.3	88.9	1.9	2.8	1.9
-52	05HX512	Holly Hyb	8805	24.41	18.02	22.74	36	38	3.8	47.4	75.2	2.0	0.9	3.5
-53	Alpine	Holly Hyb	8845	26.30	16.86	20.29	41	39	4.1	44.0	71.8	1.8	7.1	2.8
-54	04HX419	Holly Hyb	8589	24.24	17.70	21.98	30	30	4.2	28.9	65.0	2.0	4.7	2.1
-55	Beta 4430R	Betaseed	8628	24.10	17.89	22.04	39	38	3.7	45.7	78.3	1.9	4.0	1.6
-56	Beta 4001R	Betaseed	10906	29.85	18.27	21.94	44	42	3.6	51.6	85.2	1.9	2.3	0.9
-57	02HX204	Holly Hyb	7673	23.75	16.24	19.79	29	25	4.2	31.5	67.7	2.5	3.7	3.5
-58	5YK0905	Betaseed	12321	33.21	18.54	22.97	40	38	3.6	45.8	88.2	1.4	7.0	1.9
-59	R442	Crystal	6503	18.81	17.39	21.84	31	25	4.8	23.8	56.9	3.3	2.4	1.8
-60	R362	Crystal	8890	24.33	18.30	22.32	38	35	3.9	40.6	75.8	2.4	3.0	1.4
-61	4YK0503	Betaseed	11127	30.88	18.02	21.93	37	36	3.6	58.2	84.0	1.8	1.2	4.1
-62	Eagle	Holly Hyb	9404	27.12	17.31	20.89	33	31	3.8	43.0	74.8	2.1	4.5	3.1
-63	05HX503	Holly Hyb	8372	23.58	17.76	21.51	34	34	3.8	45.7	80.4	2.3	1.0	4.5
-64	04HX415	Holly Hyb	9663	26.30	18.39	22.04	37	36	3.7	47.8	82.0	1.6	1.4	1.5
-65	Beta 4014R	Betaseed	9657	27.82	17.44	21.64	36	37	4.3	36.1	64.4	1.9	3.5	4.4
USDA entries & checks														
US H11	Susc. check, 10/14/02		4234	14.14	14.95	18.74	37	36	5.5	17.9	39.7	3.3	2.2	6.5
Z210H50	C790-15CMS x Polish %S(C)		6501	18.83	17.23	21.10	38	38	4.9	28.0	47.0	3.4	2.3	4.1
Z210H5	C833-5CMS x Polish %S(C)		8628	22.62	19.06	23.53	38	38	3.9	43.2	77.6	1.9	0.9	4.1
Roberta	Susc ck, 2/25/04		5234	16.34	15.79	19.29	37	31	5.2	9.6	38.8	4.3	5.8	1.5
Beta 4430R	Resist ck, 8/21/03		8402	23.79	17.71	21.56	41	40	3.8	43.8	77.1	2.1	2.1	1.5
Angelina	Resist ck, 2/25/04		9694	26.76	18.12	22.66	35	38	3.5	57.0	87.3	1.5	2.3	5.5
Beta G017R	Resist ck(*Rz2*),7/22/04		10013	27.56	18.16	22.29	44	45	3.6	54.3	84.3	1.4	1.6	1.0

TEST 4305. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA, 2005
(cont.)

Code No.	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI %	%R (0-3) %	%R (0-4) %	Foliar Color Score	Root Rot %	PM Score
Mean			8804.1	24.79	17.71	21.65	36.9	35.9	4.1	39.5	71.5	2.1	2.8	2.6
LSD (.05)			1221.0	3.47	0.69	0.63	5.5	6.3	0.5	11.7	11.7	0.7	5.0	0.9
C.V. (%)			14.1	14.26	3.99	2.97	15.1	17.9	11.1	30.1	16.7	36.1	182.0	35.4
F Value			13.5**	10.66**	9.92**	17.74**	4.6**	4.6**	9.3**	9.6**	9.6**	5.0**	1.1NS	18.1**

NOTES: Prior to harvest, 14 plots out of the 576 total were identified as having cultural problems and missing plot analysis was used. Test 4305 was more variable than 4405. Based on the appearance of Beta4430R in adjacent buffer and border rows, one area of test 4305 also gave the impression that resistance breaking strains of BNYVV might have occurred. When available, test 4205 whose entries have different sources of resistance may help explain this situation.

Tests 105 thru 1805 were grown in Block 4 of Spence field (North 8 acres) that had been fumigated with methyl bromide/chloropicrin in 2003 and strawberries grown in 2004. No soil-borne diseases were observed. Contrarily, rhizomania tests 2105 thru 5305 were grown in the south half (8 acres) Block 4 that had a history of sugarbeet production with rhizomania and had never been fumigated with methyl bromide. In addition to rhizomania, this area had other soil-borne diseases and pests. A low level of *Sclerotium rolfsii* occurred. Initial counts of cyst nematode were 255 to 490 larvae/100 grams soil. There may also have been some incidence of soil-borne fungi such as *Fusarium, Aphanomyces,* and *Rhizoctonia.* Despite these other soil-borne problems, rhizomania appeared to be the overriding problem and greatest influence on differential yield and symptoms. The field was in an oat winter cover crop and summer fallowed in 2004. Soil pH was measured between 7.4 and 8.2 Pre-plant 12:12:12 at 424 lbs/a was applied. 21:0:0 was side-dressed on 6/6/05, 6/29/05, and 7/11/05 at about 400 lbs/a each date.

Because of the uncertainty of the severity of rhizomania (BNYVV) infestation in the trial field, the coded tests were grown in two 4-replication sets slightly separated in the trial field. Because disease pressure appeared to be nearly equal in both sets, both were hand harvested and scored on an individual root basis for rhizomania and analyzed as one 8-replication, RCB test. After a flail mower trimmed the canopy above 8-12 inches, the roots were lifted, laid out after shaking most soil off, scored on a scale of 0 to 9, topped, bagged, washed, weighed, and run through the sugar lab.

TEST 4305. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Soluble Solids	Stand Count	Harv Count	DI	%R (0-3)	%R (0-4)	Foliar Color	Root Rot	PM
		Lbs	Tons	%	%	No.	No.	%	%	%	Score	%	Score

Rhizomania scoring: Each individual root was scored for rhizomania on a scale of 0 to 9. Based on check entries, roots scored 0 to 4 were considered resistant and 5 to 9 susceptible. However, there was no discrete bi-modal curve or separation between resistant and susceptible classes. Check entries known to be *Rz1rz1* spanned from 2 to 6 with means (DI) near 4.0. Check entries known to be *rz1rz1* spanned from 3 to 9 with means (DI) near 6.0 Thus, DI may be a more true measure of variety disease reaction. % resistant will not accurately measure the frequency of the *Rz1* allele, but was obviously greatly influenced by its frequency.

Foliar score: Before harvest, the canopy was scored for yellowing possibly caused by rhizomania, where, 1 = all normal green; 2 = ±25% yellowish; 3 = 50% yellowish like rzm infected susceptible beets; 4 = ±75% yellowish; 5 = 100% yellowish like rzm infected susceptible beets.

Harvest count: Number of roots counted and scored per plot. An average of 300 roots were scored for each entry.

Stand count & Beets/100': Number of plants/100 ft. of row, counted post thinning.

Powdery mildew: Mildew was controlled until late in the season. Just prior to harvest, powdery mildew was scored on a scale of 0 to 9, where 9 = 90-100% of the leaf area covered.

%Rot: Most root rot appeared to be caused by *Sclerotium rolfsii*. Roots with partial rot were scored for rhizomania. Only roots that could not be scored were counted for %rot. All rotted roots were weighed, then removed before sugar analysis. *Sclerotium* rot appeared to be more severe on rhizomania susceptible entries.

%S, %SS and RJAP: Raw juice from the sample brei used for sugar analysis was used to measure soluble solids (refractometer). RJAP was calculated as (%S/%SS)100. For the rhizomania tests in 2005, we had trouble getting

TEST 4305. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Soluble Solids	Stand Count	Harv Count	DI	%R (0-3)	%R (0-4)	Foliar Color	Root Rot	PM
		Lbs	Tons	%	%	No.	No.	%	%	%	Score	%	Score

%S, %SS and RJAP (cont.): stable polarimeter readings from the filtrate. The polarimeter would sometimes give no value and say that sample was too dark or too turbid to read. We could not determine the reason(s) for these rhizomania-infected beets to give dark (tan, brown, yellowish, etc.) and turbid filtrates, despite adjustments in concentration of Aluminum sulfate, filtration, filteraid, etc. We do not know if rhizomania is responsible for these dark filtrates and erratic polarimeter readings, or if other diseases and/or cultural practices lead to this problem. It may be that the %SS value minus 4% is a better estimate of the %S than the polarimeter value.

Coefficients of correlation (r) were calculated:

	DI	%R(0-4)	Fol.Color	SY/A	RY/A	%S	%SS	Harv. Count
Disease Index (DI)	-.--	-0.95**	0.50**	-0.43**	-0.48**	0.00NS	0.07NS	-0.06NS
%R (0-4)	-0.95**	-.--	-0.49**	0.40**	0.45**	-0.03NS	-0.10*	0.03NS
Foliar Color	0.50**	-0.49**	-.--	-0.54**	-0.56**	-0.14**	-0.14**	-0.26**
Gross Sugar Yield (SY/A)	-0.43**	0.40**	-0.54**	-.--	0.97**	0.44**	0.38**	0.23**
Tons Roots/Acre (RY/A)	-0.48**	0.45**	-0.56**	0.97**	-.--	0.20**	0.18**	0.20**
%S	0.00NS	-0.03NS	-0.14**	0.44**	0.20**	-.--	0.87**	0.17**
%SS	0.07NS	-0.10*	-0.14**	0.38**	0.18**	0.87**	-.--	0.18**
Harvest Count	-0.06NS	0.03NS	-0.26**	0.23**	0.20**	0.17**	0.18**	-.—

TEST 4405. MICHIGAN SUGAR, WESTERN SUGAR, SOUTHERN MINNESOTA BEET SUGAR CODED HYBRID EVALUATION UNDER RHIZOMANIA, SALINAS, CA, 2005

48 entries x 8 reps (I-VIII), RCB
1-row plots, 22 ft. long

Planted: May 4, 2005
Harvested: November 1, 2005

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI %	%R (0-3) %	%R (0-4) %	Foliar Color Score	Root Rot %	PM Score
Checks & Commercial Hybrids													
Rizor	Resist ck, 3/29/01	8603	23.98	17.97	22.22	36	35	3.8	46.7	80.0	1.8	4.7	3.3
Acclaim	Resist ck, 3/15/05	8508	25.60	16.67	20.09	28	24	4.0	37.0	78.5	1.8	7.0	2.9
US H11	Susc ck, 10/14/02	4308	14.03	15.32	19.51	38	37	5.3	18.6	42.8	2.6	2.8	6.1
Monohikari	Susc ck, 1/21/03	5139	15.56	16.54	20.29	40	37	5.2	17.5	43.9	2.9	5.0	5.0
Roberta	Susc ck, 2/25/04	4710	14.97	15.58	19.09	39	32	5.5	13.6	34.8	3.9	10.8	1.6
Beta 4430R	Resist ck, 8/21/03	10092	28.27	17.89	21.77	39	37	3.5	56.7	87.2	1.9	4.1	0.9
Angelina	Resist ck, 2/25/04	9562	26.37	18.19	22.78	40	39	3.6	45.0	91.3	1.5	1.6	4.6
Beta G017R	Resist ck (*Rz*2),7/22/04	10329	28.02	18.44	22.67	44	43	3.5	59.1	88.2	1.4	4.1	0.8
Western Sugar Entries													
WS - 1	SX0231, Seedex	8359	22.24	18.83	23.24	43	40	4.2	26.2	67.7	1.9	5.1	0.3
- 2	SX0230, Seedex	8721	23.73	18.40	22.75	39	37	4.0	32.7	73.7	1.6	4.4	0.3
- 3	Beta 1344N, Betaseed	10152	29.05	17.49	22.15	39	39	3.2	69.2	94.1	1.8	5.1	4.6
4	HM 2989*Rz*, Syngenta	8577	23.90	17.96	22.71	36	36	3.6	50.8	84.9	1.4	0.0	1.9
WS - 5	HH Acclaim, Holly	7675	23.31	16.51	20.19	33	31	3.9	36.4	72.2	2.3	6.4	2.5
- 6	Beta 8400R, Betaseed	10889	29.01	18.81	23.31	47	46	3.7	55.4	82.3	1.7	3.6	0.5
- 7	Beta 4100R, Betaseed	10653	28.08	19.01	23.53	47	48	3.5	61.0	90.8	1.5	0.5	0.4
- 8	Raptor *Rz*, Seedex	8459	23.99	17.65	22.20	34	34	4.4	28.4	62.8	1.9	4.8	2.0
WS - 9	Monihikari, check	5128	15.63	16.40	19.95	43	36	5.6	15.5	31.5	3.1	8.5	4.4
Southern Minnesota Entries													
SMBSC - 1	rec'd 4/05 SM-601	11348	29.17	19.36	24.20	43	43	3.4	68.6	92.4	1.3	2.1	0.1
- 2	SM-602	8131	22.02	18.51	22.58	21	19	4.1	29.1	67.2	1.9	5.2	1.5
- 3	SM-603	8682	23.61	18.46	23.05	32	29	4.1	30.2	67.0	1.6	9.0	1.1

TEST 4405. MICHIGAN SUGAR, WESTERN SUGAR, SOUTHERN MINNESOTA BEET SUGAR CODED HYBRID EVALUATION UNDER RHIZOMANIA, SALINAS, CA, 2005
(cont.)

Variety	Description		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI %	%R (0-3) %	%R (0-4) %	Foliar Color Score	Root Rot %	PM Score
Southern Minnesota Entries (cont.)														
SMBSC - 4	rec'd 4/05	SM-604	10197	27.43	18.60	22.89	40	40	3.6	51.2	86.6	2.0	4.3	1.4
- 5		SM-605	9777	25.79	18.97	23.33	31	30	3.7	51.3	82.6	1.6	2.9	2.0
- 6		SM-606	9323	24.24	19.26	23.99	38	37	3.4	52.9	93.2	1.6	2.9	1.3
Monohikari	Susc.ck, 1/21/03		5853	17.22	16.92	20.86	42	39	5.2	21.8	49.4	2.8	5.3	4.6
Michigan Sugar Entries														
HM -E17	Susc ck,4/05	Mich.Sugar	4796	14.19	16.75	20.88	35	32	6.1	11.3	22.8	3.4	5.4	3.8
MS - 1	rec'd 4/05	RM- 1	9183	25.02	18.37	23.21	35	35	3.7	52.6	84.2	1.5	3.0	1.3
MS - 2		RM- 2	9773	25.26	19.39	23.24	42	42	3.4	63.2	93.5	1.3	0.0	3.5
MS - 3		RM- 3	7998	21.19	18.89	23.58	39	38	4.0	38.6	73.0	2.1	2.1	1.5
MS - 4	rec'd 4/05	RM- 4	10688	28.61	18.72	23.68	37	39	3.2	62.9	93.4	1.0	0.3	3.1
MS - 5		RM- 5	7894	21.38	18.49	22.97	37	37	4.7	30.8	53.5	2.1	5.2	2.4
MS - 6		RM- 6	9729	26.04	18.72	23.04	40	41	3.8	41.0	79.6	1.4	1.6	1.3
MS - 7		RM- 7	7235	19.04	18.86	23.21	33	32	4.8	28.6	49.3	2.1	3.5	2.5
MS - 8	rec'd 4/05	RM- 8	9708	26.17	18.57	22.70	38	38	3.5	57.2	92.3	1.6	0.7	2.8
MS - 9		RM- 9	8815	24.56	17.97	22.41	34	32	3.9	41.0	77.4	1.5	9.5	0.9
MS -10		RM-10	9158	23.92	19.24	23.63	41	42	3.6	49.5	86.4	1.0	1.4	0.8
MS -11		RM-11	9128	24.79	18.44	23.06	41	41	3.8	40.2	77.7	1.5	1.8	1.9
MS -12	rec'd 4/05	RM-12	8571	23.01	18.64	23.45	38	36	3.6	49.8	87.4	2.4	3.9	0.8
HM -E17	Susc ck,4/05	Mich.Sugar	4352	12.87	16.79	20.90	37	34	6.1	9.2	22.8	3.6	2.7	3.4
MS -13	rec'd 4/05	RM-13	9901	26.29	18.84	23.48	43	44	3.2	69.2	93.2	1.1	0.3	3.0
MS -14		RM-14	9169	24.71	18.57	22.98	37	37	3.9	43.8	71.9	1.3	3.1	1.1
MS -15	rec'd 4/05	RM-15	10776	27.99	19.27	23.75	37	37	3.6	53.3	86.7	1.0	0.0	2.8
MS -16		RM-16	8957	23.91	18.75	23.31	40	39	3.7	46.8	87.3	1.8	2.6	0.9
MS -17		RM-17	7588	20.06	18.93	23.53	37	35	4.8	31.1	52.5	2.0	3.3	2.5
MS -18		RM-18	4149	12.23	16.78	21.22	21	20	6.6	5.9	15.8	3.5	1.3	4.3

TEST 4405. MICHIGAN SUGAR, WESTERN SUGAR, SOUTHERN MINNESOTA BEET SUGAR CODED HYBRID EVALUATION UNDER RHIZOMANIA, SALINAS, CA, 2005
(cont.)

Variety	Description		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Soluble Solids %	Stand Count No.	Harv Count No.	DI %	%R (0-3) %	%R (0-4) %	Foliar Color Score	Root Rot %	PM Score
Michigan Sugar Entries (cont.)														
MS -19	rec'd 4/05	RM-19	8358	21.41	19.51	24.72	35	32	4.1	43.2	67.5	1.6	7.3	1.5
MS -20		RM-20	8772	24.14	18.19	22.86	41	41	3.7	41.0	81.2	1.0	2.4	1.6
MS -21		RM-21	9206	25.95	17.75	21.82	39	34	4.2	34.8	69.6	2.0	9.9	1.0
MS -22		RM-22	7074	18.61	18.96	23.61	37	35	4.6	32.9	53.3	2.5	7.5	2.4
Mean			8419.8	23.1	18.15	22.51	37.5	36.2	4.1	40.7	71.2	1.9	3.9	2.2
LSD (.05)			1135.6	3.1	0.55	0.57	4.2	5.4	0.4	11.4	10.7	0.6	6.2	0.9
C.V. (%)			13.7	13.7	3.10	2.57	11.4	15.0	10.6	28.6	15.2	29.9	159.4	42.3
F value			21.7**	17.0**	26.57**	40.95**	11.5**	9.0**	28.1**	16.3**	30.7**	12.3**	1.5*	19.8**

NOTES: Tests 105 thru 1805 were grown in Block 4 of Spence field (North 8 acres) that had been fumigated with methyl bromide/chloropicrin in 2003 and strawberries grown in 2004. No soil-borne diseases were observed. Contrarily, rhizomania tests 2105 thru 5305 were grown in the south half (8 acres) Block 4 that had a history of sugarbeet production with rhizomania and had never been fumigated with methyl bromide. In addition to rhizomania, this area had other soil-borne diseases and pests. A low level of *Sclerotium rolfsii* occurred. Initial counts of cyst nematode were 255 to 490 larvae/100 grams soil. There may also have been some incidence of soil-borne fungi such as *Fusarium, Aphanomyces,* and *Rhizoctonia.* Despite these other soil-borne problems, rhizomania appeared to be the overriding problem and greatest influence on differential yield and symptoms. The field was in an oat winter cover crop and summer fallowed in 2004. Soil pH was measured between 7.4 and 8.2 Pre-plant 12:12:12 at 424 lbs/a was applied. 21:0:0 was side-dressed on 6/6/05, 6/29/05, and 7/11/05 at about 400 lbs/a each date.

Because of the uncertainty of the severity of rhizomania (BNYVV) infestation in the trial field, the coded tests were grown in two 4-replication sets slightly separated in the trial field. Because disease pressure appeared to be nearly equal in both sets, both were hand harvested and scored on an individual root basis for rhizomania and analyzed as one 8-replication, RCB test. After a flail mower trimmed the canopy above 8-12 inches, the roots were lifted, laid out after shaking most soil off, scored on a scale of 0 to 9, topped, bagged, washed, weighed, and run through the sugar lab.

TEST 4405. MICHIGAN SUGAR, WESTERN SUGAR, SOUTHERN MINNESOTA BEET SUGAR CODED HYBRID EVALUATION UNDER RHIZOMANIA, SALINAS, CA, 2005
(cont.)

Variety	Description	Acre Yield Sugar	Beets	Sucrose	Soluble Solids	Stand Count	Harv Count	DI	%R (0-3)	%R (0-4)	Foliar Color	Root Rot	PM
		Lbs	Tons	%	%	No.	No.	%	%	%	Score	%	Score

Rhizomania scoring: Each individual root was scored for rhizomania on a scale of 0 to 9. Based on check entries, roots scored 0 to 4 were considered resistant and 5 to 9 susceptible. However, there was no discrete bi-modal curve or separation between resistant and susceptible classes. Check entries known to be *Rz1rz1* spanned from 2 to 6 with means (DI) near 4.0. Check entries known to be *rz1rz1* spanned from 3 to 9 with means (DI) near 6.0 Thus, DI may be a more true measure of variety disease reaction. % resistant will not accurately measure the frequency of the *Rz1* allele, but was obviously greatly influenced by its frequency.

Foliar score: Before harvest, the canopy was scored for yellowing possibly caused by rhizomania, where, 1 = all normal green; 2 = ±25% yellowish; 3 = 50% yellowish like rzm infected susceptible beets; 4 = ±75% yellowish; 5 = 100% yellowish like rzm infected susceptible beets.

Harvest count: Number of roots counted and scored per plot. An average of 300 roots were scored for each entry.

Stand count & Beets/100': Number of plants/100 ft. of row, counted post thinning.

Powdery mildew: Mildew was controlled until late in the season. Just prior to harvest, powdery mildew was scored on a scale of 0 to 9, where 9 = 90-100% of the leaf area covered.

%Rot: Most root rot appeared to be caused by *Sclerotium rolfsii*. Roots with partial rot were scored for rhizomania. Only roots that could not be scored were counted for %rot. All rotted roots were weighed, then removed before sugar analysis. *Sclerotium* rot appeared to be more severe on rhizomania susceptible entries.

%S, %SS and RJAP: Raw juice from the sample brei used for sugar analysis was used to measure soluble solids (refractometer). RJAP was calculated as (%S/%SS)100. For the rhizomania tests in 2005, we had trouble getting stable polarimeter readings from the filtrate. The polarimeter would sometimes give no value and say that sample was too dark or too turbid to read. We could not determine the reason(s) for these rhizomania-infected beets to

TEST 4405. MICHIGAN SUGAR, WESTERN SUGAR, SOUTHERN MINNESOTA BEET SUGAR CODED HYBRID EVALUATION UNDER RHIZOMANIA, SALINAS, CA, 2005 (cont.)

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Soluble Solids	Stand Count	Harv Count	DI	%R (0-3)	%R (0-4)	Foliar Color	Root Rot	PM
		Lbs	Tons	%	%	No.	No.	%	%	%	Score	%	Score

%S, %SS and RJAP (cont.): give dark (tan, brown, yellowish, etc.) and turbid filtrates, despite adjustments in concentration of Aluminum sulfate, filtration, filteraid, etc. We do not know if rhizomania is responsible for these dark filtrates and erratic polarimeter readings, or if other diseases and/or cultural practices lead to this problem. It may be that the %SS value minus 4% is a better estimate of the %S than the polarimeter value.

Coefficients of correlation (r) were calculated:

	DI	%R(0-4)	Fol.Color	SY/A	RY/A	%S	%SS	Harv. Count
Disease Index (DI)	-.--	-0.99**	0.89**	-0.94**	-0.94**	-0.66**	-0.63**	-0.47**
%R (0-4)	-0.99**	-.--	-0.87**	0.93**	0.93**	0.64**	0.61**	0.49**
Foliar Color	0.89**	-0.87**	-.--	-0.88**	-0.86**	-0.73**	-0.71**	-0.42**
Gross Sugar Yield (SY/A)	-0.94**	0.93**	-0.88**	-.--	0.98**	0.74**	0.71**	0.48**
Tons Roots/Acre (RY/A)	-0.94**	0.93**	-0.86**	0.98**	-.--	0.62**	0.58**	0.45**
%S	-0.66**	0.64**	-0.73**	0.74**	0.62**	-.--	0.97**	0.36*
%SS	-0.63**	0.61**	-0.71**	0.71**	0.58**	0.97**	-.--	0.36*
Harvest Count	-0.47**	0.49**	-0.42**	0.48**	0.45**	0.36*	0.36*	-.--

TEST B105. EVALUATION OF TOPCROSS HYBRIDS, IMPERIAL VALLEY, CA, 2004-2005

24 entries x 8 reps., RCB(E)
1-row plots, 18 ft. long

Planted: September 16, 2004
Harvested: June 1, 2005

Variety	Description		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N ppm	NO3-N score
Checks										
Phoenix	9/12/03		13699	51.77	13.23	147	2.3	93.0	286	5.5
Beta 4430R	8/21/03		16210	55.07	14.75	152	0.4	88.6	256	5.3
Topcrosses with Y91										
Y491H50	C790-15CMS	x Y391	12205	43.25	14.11	138	0.0	92.0	243	5.3
Y491H5	C833-5HO	x Y391	13546	47.23	14.35	142	0.9	90.6	165	4.6
Y491H77	1833-5-8HO	x Y391	14145	48.82	14.52	139	0.0	91.2	181	4.8
Y491H78	1833-5-11HO	x Y391	12669	43.69	14.51	128	0.0	91.2	152	4.6
Y491H14	3869-24H5	x Y391	12170	45.09	13.49	149	0.0	90.9	265	5.4
Y491H15	3869-27H5	x Y391	12541	47.05	13.27	145	0.0	91.6	227	5.0
Y491H16	3869-30H5	x Y391	12477	46.07	13.55	144	0.0	93.0	246	5.3
Y491H67	3837-6HO	x Y391	12084	43.14	13.98	134	0.0	89.3	177	4.6
Y491H75	03-FC123-31H5	x Y391	11966	42.15	14.20	139	0.0	86.8	221	5.3
Y491H76	03-FC1014-22H5	x Y391	11920	41.15	14.50	138	1.0	90.4	170	4.5
Y491H73	03-FC124HO	x Y391	12983	48.11	13.51	142	0.6	91.3	275	5.4
Y491H74	03-FC1015HO	x Y391	11724	40.86	14.35	144	5.4	92.2	186	5.0
Y491H42	3842HO (C842CMS)	x Y391	12644	47.51	13.27	149	0.0	91.9	254	5.0
Y491H70	3869HO (C869CMS)	x Y391	12304	47.65	12.92	145	0.0	92.3	287	5.5
Testcross hybrids with RKN resistance										
K402H5	C833-5HO x RKNR M6-2		13322	49.17	13.57	133	0.0	91.2	248	5.3
K403H5	C833-5HO x RKNR M1-3,-3a		13675	52.11	13.14	152	5.2	90.4	260	5.3
K404H5	C833-5HO x RKNR M1-4		14236	49.92	14.27	151	0.0	90.3	169	4.6
Testcross hybrids with selected progeny lines										
R480-6H5	C833-5HO x R280-6		13328	45.04	14.78	142	0.0	88.8	155	4.4
4941-20H5	C833-5HO x 2941-20		14375	49.28	14.58	143	0.0	91.3	138	4.5

TEST B105. EVALUATION OF TOPCROSS HYBRIDS, IMPERIAL VALLEY, CA, 2004-2005 (cont.)

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Beets/ 100'	Bolters	Clean Beets	NO3-N	NO3-N
		Lbs	Tons	%	No.	%	%	ppm	score
Testcross hybrids with selected progeny lines (cont.)									
4933-14H5	C833-5HO x 2933-14	13981	46.87	14.89	147	0.6	90.1	150	4.5
Z431-18H5	C833-5HO x Z131-18	12754	43.64	14.62	149	0.0	90.0	133	4.4
P318-6H5	C833-5HO x P118-6, (CP08)	13129	45.27	14.50	147	0.0	87.9	176	4.6
Mean		13087.0	46.66	14.04	143.3	0.7	90.7	209.1	4.9
LSD (.05)		1324.4	4.13	0.68	8.9	1.7	3.2	60.2	0.5
C.V. (%)		10.3	8.98	4.90	6.3	248.1	3.6	29.2	11.2
F value		4.7**	5.81**	6.25**	3.7NS	6.4**	1.8*	5.6**	3.8**

TEST B205. PERFORMANCE OF HYBRIDS CORRESPONDING TO ENTRIES IN SBCN/RHIZOMANIA TESTS, IMPERIAL VALLEY, CA, 2004-2005

48 entries x 8 reps., RCB(E)
1-row plots, 18 ft. long

Planted: September 16, 2004
Harvested: June 2, 2005

Variety		Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N ppm	NO3-N score
Checks										
HH142	9-12-03	Holly Hybrids	12934	48.15	13.40	157	1.0	93.8	326	5.8
Beta 4430R	8-21-03	Betaseed	17517	58.24	14.95	175	0.0	88.1	241	5.3
Phoenix	9-12-03	Holly Hybrids	13549	51.01	13.27	156	0.4	95.0	330	5.6
Beta 4001R	8-21-03	Betaseed	15917	57.06	13.96	171	0.7	89.9	321	5.5
Angelina	2-25-04		13356	44.38	15.06	156	0.9	89.6	219	5.1
US H11	susc. check		9032	36.25	12.54	167	0.0	88.0	294	5.3
Roberta	2-25-04		15906	59.34	13.38	158	0.4	91.6	199	5.0
SBCNR hybrids from seed companies										
2VK0305	8/04	Betaseed	11936	44.59	13.39	149	2.4	89.2	298	5.5
OVK6280	8/04	Betaseed	10852	41.04	13.19	152	0.0	85.5	219	5.1
2AP0852	8/04	Betaseed	13592	45.30	15.08	162	2.6	92.0	319	5.6
2EN5066	8/04	Betaseed	12958	44.63	14.47	168	2.6	88.9	255	5.1
HXN1	9/7/04	Holly Hybrids	11171	41.72	13.44	151	1.5	93.2	273	5.5
HXN2	9/7/04	Holly Hybrids	11209	38.56	14.61	161	3.5	91.9	232	5.0
Hil-1	8/04	Syngenta	10391	39.21	13.33	153	31.1	89.6	291	5.3
Hil-2	8/04	Syngenta	10373	39.44	13.16	159	6.4	88.7	308	5.6
Hil-3	8/04	Syngenta	9676	40.01	12.29	163	2.1	88.3	282	5.4
USDA breeding lines and their hybrids										
N412(Sp)	N212-#(C), N312aa x A, (CN12)		9854	37.26	13.28	140	5.1	92.4	218	5.1
N472(Sp)	N272-#(C), N372aa x A, (CN72)		10168	40.59	12.48	166	15.7	90.1	463	6.1
Y475	RZM-ER-% Y275		10088	36.45	13.86	165	5.6	92.2	232	5.1
Y475H5	C833-5HO x RZM-ER-% Y275		12687	42.99	14.73	161	2.9	89.6	170	4.8

TEST B205. PERFORMANCE OF HYBRIDS CORRESPONDING TO ENTRIES IN SBCN/RHIZOMANIA TESTS, IMPERIAL VALLEY, CA, 2004-2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N ppm	NO3-N score
USDA breeding lines and their hybrids (cont.)									
Y477H5	C833-5HO x RZM-ER-% Y277	12295	43.05	14.25	158	2.9	93.1	213	5.0
N412H5	C833-5HO x N212-#(C),N312,(CN12)	11149	38.65	14.42	158	1.7	89.9	160	4.5
N472H5	C833-5HO x N272-#(C),N372,(CN72)	12519	45.28	13.80	152	4.0	90.1	204	5.0
1927-4H5	C833-5HO x RZM 9927-4 (C927-4)	12510	43.84	14.28	156	1.2	91.4	163	4.6
P431H5	C833-5HO x RZM,CTR R278,P230,P207/8	12996	45.84	14.22	156	0.4	91.9	152	4.5
Y467-21H50	C790-15CMS x RZM Y267-21	12990	46.53	14.01	161	2.3	91.7	303	5.8
Y471-14H50	C790-15CMS x RZM Y271-14	13301	44.60	14.87	158	0.0	86.8	148	4.6
R443-14H50	C790-15CMS x RZM R243-14	12788	46.07	13.85	168	5.0	90.0	191	4.9
N412H50	C790-15CMS x N212-#(C),N312,(CN12)	11760	42.57	13.79	163	5.5	90.0	247	5.3
N472H50	C790-15CMS x N272-#(C),N372,(CN72)	11766	45.79	12.85	152	5.3	90.7	436	6.0
4927-202H50	C79-15CMS x 2927-4-202	12633	42.23	14.99	179	0.8	88.1	158	4.5
N424H5	C833-5HO x RZM N324-#(C)(g)	11966	41.81	14.36	154	1.0	90.1	174	4.6
Hybrids with progeny lines selected for I.V. performance									
N412-6H5	C833-5HO x N212-6	11402	37.68	15.10	111	2.1	89.0	130	4.3
N412-11H5	C833-5HO x N212-11	12240	43.47	14.13	111	1.4	89.9	144	4.5
N412-13H5	C833-5HO x N212-13 (susc.ck.)	14254	51.18	13.93	150	0.0	91.2	168	4.6
N412-202H5	C833-5HO x N212-202	13426	45.81	14.71	152	0.0	89.7	147	4.4
N412-203H5	C833-5HO x N212-203	14710	51.01	14.40	156	0.0	88.6	208	4.9
N412-205H5	C833-5HO x N212-205	13066	44.21	14.78	158	0.0	92.3	183	4.8
N472-230H5	C833-5HO x N272-230	13644	51.77	13.21	145	0.6	91.9	250	5.4
N472-231H5	C833-5HO x N272-231	10357	38.48	13.72	70	28.8	92.6	214	4.8
N472-233H5	C833-5HO x N272-233	13247	51.84	12.77	148	0.0	93.6	366	5.9
4926-11-3-22H5	C833-5HO x 2926-11-3-22	13498	44.78	15.11	161	0.5	90.2	100	4.0
4926-11-1-3H5	C833-5HO x 2926-11-1-3	13049	43.68	14.97	160	0.4	91.8	112	3.9

TEST B205. PERFORMANCE OF HYBRIDS CORRESPONDING TO ENTRIES IN SBCN/RHIZOMANIA TESTS, IMPERIAL VALLEY, CA, 2004-2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N ppm	NO3-N score
Hybrids with progeny lines selected for I.V. performance (cont.)									
4926-11-7-61H5	C833-5HO x 2926-11-7-61	12226	39.26	15.61	154	0.0	90.4	128	4.0
4926-11-10-91H5	C833-5HO x 2926-11-10-91	12914	40.96	15.78	147	1.8	90.0	121	4.3
Topcross hybrids with Bp-mm females for SBCNR									
Y491H5	C833-5HO x Y391	13603	45.59	14.98	140	0.4	92.5	151	4.4
Y491H93	N365-31HO(g) x Y391	11182	41.72	13.40	137	0.0	92.0	293	5.4
Y491H99	N369HO(g) x Y391	12397	44.03	14.08	151	0.0	90.4	206	5.0
Mean		12438.6	44.33	14.05	153.3	3.1	90.6	228.3	5.0
LSD (.05)		1701.5	5.84	0.73	14.4	5.6	2.6	77.2	0.5
C.V. (%)		13.9	13.38	5.30	9.5	179.8	2.9	34.3	11.0
F value		7.5**	6.52**	10.33**	11.6**	9.9**	4.1**	8.7**	7.8**

See Test B505 for performance under SBCN/rhizomania conditions.

4927-202 = CN927-202 = 4926-11-22 = CN92-11-3-22.

Soil cores to count SBCN were taken on 1/25/05 and at harvest 6/01/05 for entries Beta 4430R, Phoenix, 2AP0852 and Hil-2. Average counts (egg+larvae)/100g soil were: 0.0, 0.0, 0.0 and 0.0 on 1/25/05 and 0.0, 0.0, 0.0, and 0.0 on 6/01/05, respectively. Soil cores were taken from each replication of the above entries. A composite of all replications was made per each variety and used to count nematodes. These counts show that test B205 did not have SBCN.

Tests B205 and B505 are repeated at Salinas in 2005 as Tests 905 and 1005, without SBCN/rhizomania; and Tests 4705 and 4305 under SBCN/rhizomania conditions.

From the soil samples used to count cyst nematode, tests were run in the greenhouse to determine if there was BNYVV (rhizomania) in these trials. Based upon the ELISA results of the baited plants. Fields J and K at Brawley do not have rhizomania. Also, BOLV was not present.

TEST B305. EVALUATION OF HYBRIDS WITH SELECTED PROGENY LINE POLLINATORS,
IMPERIAL VALLEY, CA, 2004-2005

48 entries x 8 reps., RCB(E)
1-row plots, 18 ft. long

Planted: September 16, 2004
Harvested: June 3, 2005

Variety		Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N ppm	NO3-N score
Checks										
Beta 4001R	8/21/03	Betaseed	12696	44.83	14.17	163	1.1	94.7	308	5.6
Phoenix	9/12/03	Holly Hybrids	10025	36.77	13.71	154	0.0	96.3	298	5.5
HH142	9/12/03	Holly Hybrids	9953	37.20	13.30	158	1.4	96.8	332	5.6
Beta 4430R	8/21/03	Betaseed	12807	42.55	15.01	165	0.4	94.3	263	5.3
Populations hybrids										
4931H50	C790-15CMS x 3931 (C931)		9885	34.42	14.27	150	2.2	93.8	254	5.3
4941H50	C790-15CMS x 3941 (C941)		10830	37.77	14.27	158	0.5	96.0	227	5.0
CR411H50	C790-15CMS x CR311 (CR11)		9504	34.50	13.71	156	1.0	95.6	290	5.3
Z425H50	C790-15CMS x Z325 (CZ25)		9298	32.20	14.44	152	3.8	94.9	276	5.5
4943H50	C790-15CMS x 3943		10010	33.44	14.94	149	0.5	95.5	230	4.9
N412H50	C790-15CMS x N212-#(C),N312,(CN12)		10183	37.96	13.46	160	4.6	95.2	304	5.4
N472H50	C790-15CMS x N272-#(C),N372,(CN72)		10113	38.28	13.23	158	5.3	93.6	400	6.0
P318-6H50	C790-15CMS x P118-6, (CP08)		10186	35.00	14.56	154	2.8	92.8	230	5.3
P207/8H50	C790-15CMS x P007/8, (CP07)		10241	37.79	13.61	153	0.9	95.1	304	5.3
04-FC1028H5	C833-5HO x RZM-% FC20021028		11687	41.25	14.21	155	0.9	94.6	179	4.9
04-FC1037H5	C833-5HO x RZM-% FC20021037		9662	34.82	13.86	155	1.4	94.8	262	5.4
04-FC1038H5	C833-5HO x RZM-% FC20021038		8833	32.69	13.61	133	5.4	93.5	206	4.8
Experimental hybrids and retests										
Y491H50	C790-15CMS x Y391		10077	35.17	14.32	144	0.5	96.9	229	5.1
R421H5	C833-5HO x RZM-ER-% R221		10634	38.50	13.84	154	0.5	95.7	201	4.9
R480-6H50	C790-15CMS x R280-6		12314	42.14	14.69	160	0.8	95.0	209	5.0
4941-20H50	C790-15CMS x 2941-20		10916	36.68	14.90	153	0.0	95.4	200	5.0
4933-14H50	C790-15CMS x 2933-14		11132	36.82	15.14	150	0.0	96.1	214	4.9
Z431-18H50	C790-15CMS x Z131-18		9827	34.99	14.04	155	0.0	95.3	207	4.6
Z425-214H50	C790-15CMS x Z225-214		10949	36.49	15.07	164	0.4	93.2	155	4.8
4929-221H50	C790-15CMS x 2929-112-221		10822	35.72	15.15	156	2.3	94.3	202	4.9

TEST B305. EVALUATION OF HYBRIDS WITH SELECTED PROGENY LINE POLLINATORS, IMPERIAL VALLEY, CA, 2004-2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N ppm	NO3-N score
Experimental hybrids and retests (cont.)									
4929-227H50	C790-15CMS x 2929-112-227	11662	40.77	14.31	151	0.0	96.0	298	5.6
4930-229H50	C790-15CMS x 2930-35-229	11703	39.06	15.01	169	0.0	95.1	221	5.0
S_1 progeny lines from CR popns & lines									
CR410-231H50	C790-15CMS x CR210-14-2-231	9728	35.07	13.82	153	0.0	94.0	258	5.1
CR412-211H50	C790-15CMS x CR212-5-211	10781	36.98	14.66	159	6.9	91.5	246	5.3
CR412-5H50	C790-15CMS x CR212-5-211,-212-216,-218	11143	38.12	14.68	160	2.1	95.3	195	4.9
CR410-203H50	C790-15CMS x CR210-5-203	11001	36.90	14.92	158	0.0	93.2	185	4.8
S_1 progeny line from popn-924									
4924-203H50	C790-15CMS x 2924-203	11215	38.10	14.71	157	6.2	94.5	231	5.0
S_1 progeny lines from popn-942 (R576-89-18H18)									
4942-202H50	C790-15CMS x 2942-202	10981	36.50	15.05	163	0.0	93.4	171	4.5
4942-209H50	C790-15CMS x 2942-209	11570	38.71	14.94	154	0.4	92.0	167	4.6
4942-211H50	C790-15CMS x 2942-211	9926	34.54	14.41	155	0.0	94.6	257	5.1
S_1 progeny line from F_1 hybrid (CR11 x Y90)									
4951-210H50	C790-15CMS x 2951-210	11025	38.66	14.32	152	4.4	95.0	241	5.0
S_1 progeny line from F_1 hybrid (Z25 x Y90)									
4952-202H50	C790-15CMs x 2952-202	12748	41.91	15.15	158	0.0	93.3	154	4.4
4952-205H50	C790-15CMs x 2952-205	10129	32.61	15.58	155	0.0	93.2	186	4.8
4952-212H50	C790-15CMS x 2952-212	10630	35.36	15.00	150	2.0	94.8	123	3.9
4952-222H50	C790-15CMS x 2952-222	10695	33.62	15.92	161	4.0	92.5	109	4.0

TEST B305. EVALUATION OF HYBRIDS WITH SELECTED PROGENY LINE POLLINATORS, IMPERIAL VALLEY, CA, 2004-2005
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N ppm	NO3-N score
S_1 progeny lines from F_1 hybrid (931 x Y90)									
4953-209H50	C790-15CMS x 2953-209	11822	38.48	15.37	153	0.0	93.7	190	4.8
4953-215H50	C790-15CMS x 2953-215	10236	35.06	14.60	145	3.2	95.6	264	5.3
4953-217H50	C790-15CMS x 2953-217	11054	37.74	14.65	153	3.9	94.2	140	4.3
S_1 progeny lines from F_1 hybrid (941 x Y90)									
4954-204H50	C790-15CMS x 2954-204	11629	38.29	15.16	159	0.0	95.7	215	5.0
4954-207H50	C790-15CMS x 2954-207	11994	41.74	14.39	152	0.5	94.0	245	5.1
4954-210H50	C790-15CMS x 2954-210	9735	30.82	15.79	157	0.0	91.6	124	4.1
4954-213H50	C790-15CMS x 2954-213	10922	38.02	14.37	156	1.4	94.2	282	5.5
4954-225H50	C790-15CMS x 2954-225	10686	36.41	14.70	163	0.9	92.4	178	4.8
4954-231H50	C790-15CMS x 2954-231	11027	39.75	13.89	133	1.2	94.7	243	5.1
Mean		10763.0	37.11	14.52	154.9	1.5	94.5	227.0	5.0
LSD (.05)		1470.6	4.73	0.77	14.5	2.5	1.9	77.5	0.6
C.V. (%)		13.9	12.94	5.38	9.5	165.1	2.1	34.7	12.4
F value		3.0**	2.95**	5.27**	1.7NS	4.4**	3.5**	4.4**	3.9**

TEST B405. HYBRIDS WITH COMBINED RESISTANCE TO SBCN & RHIZOMANIA, IMPERIAL VALLEY, CA, 2004-2005

24 entries x 8 reps., RCB(E)
1-row plots, 18 ft. long

Planted: September 15, 2004
Harvested: June 8, 2005

Variety	Resistance			Description	Acre Yield				Beets/		Clean		
					Sugar	Relative	Beets	Sucrose	100'	Bolters	Beets	NO3-N	Canopy
	Rz	NR1	NR2		Lbs	SY(%)	Tons	%	No.	%	%	ppm	score
Checks													
Phoenix	√			Commercial check	6927	51.1	24.41	14.21	165	0.0	96.0	249	3.9
US H11				Susc. check	4579	50.7	17.00	13.47	165	0.0	91.9	269	3.4
Roberta				Susc. check	7769	48.8	23.99	16.13	153	0.0	95.7	152	3.0
Beta 4430R	√			Commercial check	6440	36.8	20.80	15.46	165	0.0	95.7	154	3.0
OVK6280		√		9/12/03, Betaseed	7544	69.5	27.26	13.75	160	0.4	94.0	281	2.5
2EN5066			√	9/12/03, Betaseed	12861	99.3	41.11	15.68	163	0.0	96.0	233	2.1
Hil-3		√		4/22/03, Syngenta	8574	88.6	32.30	13.31	161	0.0	94.8	356	2.9
HXN1	√	√		9/7/04, Holly	7085	63.4	23.98	14.85	153	0.4	94.6	257	2.4
HXN2	√		√	9/7/04, Holly	4857	43.3	16.99	14.35	161	0.0	95.8	239	3.3
USDA experimental hybrids													
N412H5	√		√	C833-5HO x N212-#(C)	7459	75.7	26.15	14.28	157	0.0	94.8	203	1.8
N472H5	√		√	C833-5HO x N272-#(C)	8800	86.5	32.01	13.77	161	0.8	94.5	334	2.0
N424H5	√	√		C833-5HO x N324-#(C)(g)	5394	45.1	17.04	15.67	148	0.0	92.1	113	3.0
1927-4H5	√		√	C833-5HO x RZM 9927-4	8839	70.7	30.93	14.32	161	0.0	95.8	236	2.0
4926-11-1-3H5	√		√	C833-5HO x 2926-11-1-3	7719	59.2	24.40	15.82	160	0.0	95.4	136	2.1
4926-11-10-91H5	√		√	C833-5HO x 2926-11-10-91	10688	82.8	33.53	15.97	164	0.0	94.5	138	1.6
R443-14H50	√		√	C790-15CMS x R243-14	6769	52.9	25.18	13.56	163	0.9	93.8	253	2.5
Y471-14H50	√		√	C790-15CMS x Y271-14	7453	56.0	25.15	14.88	161	0.0	93.9	192	2.4
Y467-21H50	√		√	C790-15CMS x Y267-21	7656	58.9	28.71	13.39	154	0.0	95.4	354	1.9
Y475H5	√		√	C833-5HO x Y275	9148	72.1	31.47	14.59	160	0.0	95.3	214	2.1
Y477H5	√		√	C833-5HO x Y277	7912	64.4	27.07	14.63	159	0.0	96.2	197	2.3
Topcross hybrids with Y91													
Y491H5	√			C833-5HO x Y391	5871	43.2	18.72	15.62	149	0.0	95.6	152	2.6
Y491-H99	√	√		N369HO(g) x Y391	6082	49.1	21.79	14.03	148	0.0	94.6	251	3.0
Y491H93	√	√		N365-31HO(g) x Y391	5819	52.0	22.54	12.87	151	0.0	96.3	384	2.1
Y491H94	√	√		N365-9HO(g) x Y391	7865		27.44	14.38	156	0.0	93.1	232	2.1

TEST B405. HYBRIDS WITH COMBINED RESISTANCE TO SBCN & RHIZOMANIA,
IMPERIAL VALLEY, CA, 2004-2005
(cont.)

Variety	Resistance			Description	Acre Yield				Beets/		Clean		
					Sugar	Relative	Beets	Sucrose	100'	Bolters	Beets	NO3-N	Canopy
	Rz	NR1	NR2		Lbs	SY(%)	Tons	%	No.	%	%	ppm	score
Mean					7504.6		25.8	14.5	158.3	0.1	94.8	232.4	2.5
LSD (.05)					1358.9		4.7	0.7	9.8	0.6	1.9	67.6	0.6
C.V. (%)					18.4		18.5	5.1	6.3	540.6	2.0	29.5	23.0
F value					14.0**		12.1**	13.1**	2.5NS	1.6*	3.2**	9.2**	7.8**

Rz = Holly (Rz1) or other sources of resistance to rhizomania.
NR1 = *B.procumbens* source of nematode resistance.
NR2 = Possible other sources of nematode resistance or tolerance.

Relative Sugar Yield (%) was calculated between the mean of the variety in test B404 under SBCN/Rhizomania conditions and Test B205 under nondiseased conditions.

See Test B505 notes for canopy score.

Phoenix and Beta 4430R plots were sampled for nematodes. Eight cores were taken and composited per plot on 1/25/05 and 6/6/05. The mean counts/100g soil were 6013 and 8243 on 1/25/05 and 4329 and 4645 on 6/6/05 for Phoenix and Beta 4430R, respectively.

N412 = CN12. N472 = CN72. 1927-4 = C927-4. N369HO and N365-31HO segregate for *Hs-1*. N365-9HO and N365-31HO segregate for *Hs-1*. N365-9HO may be homozygous *Hs-1 Hs-1*. H5 = hybrids with *Rz*1 monogerm C833-5CMS. H50 = hybrids with *rzrz* monogerm C790-15CMS.

Test B405 was grown on Field K under high populations of cyst nematode and mild rhizomania.

Following harvest, the area for tests B405 & B505 was disked and soil collected randomly for nematode counts. Mean counts of 5442 eggs & larvae were obtained. This soil will be used for future greenhouses biological tests.

From the soil samples used to count cyst nematode, tests were run in the greenhouse to determine if there was BNYVV (rhizomania) in these trials. Based upon the ELISA results of the baited plants, Fields J and K at Brawley do not have rhizomania. Also, BOLV was not present.

TEST B505. HYBRIDS WITH COMBINED RESISTANCE TO SBCN & RZM FROM VARIOUS SOURCES, IMPERIAL VALLEY, CA, 2004-2005

24 entries x 8 reps., RCB(E)
2-row plots, 18 ft. long

Planted: September 15, 2004
Harvested: June 7, 2005

Variety	Resistance			Description	Acre Yield			Sucrose	Beets/ 100'	Bolters	Clean Beets	NO3-N	Canopy
	Rz	NR1	NR2		Sugar Lbs	Relative SY(%)	Beets Tons	%	No.	%	%	ppm	score
Checks													
Beta 4430R	Y			Rhizomania resist ck	8235	47.0	27.41	15.06	155	0.0	95.9	225	3.3
Phoenix	√			Commercial check	6538	48.3	23.70	13.75	157	0.0	95.8	255	3.6
Roberta				Susc. check	8488	53.4	26.77	15.86	157	0.0	94.7	167	2.9
US H11				Susc. check	5535	61.3	20.22	13.63	158	0.0	92.4	247	3.4
Syngenta hybrids													
Hil-1	√	√		8/04	9040	87.0	32.63	13.86	154	0.8	95.3	276	3.5
Hil-2	√	√		8/04	8801	84.8	32.04	13.74	148	1.2	95.9	360	2.9
Hil-3		√		8/04	9940	102.7	36.58	13.60	157	0.0	94.9	365	2.4
Holly hybrids													
HXN1	√	√		9/7/04	8942	80.0	30.99	14.42	150	0.2	96.6	283	2.0
HXN2	√		√	9/7/04	6672	59.5	22.97	14.54	161	0.0	95.1	253	3.3
Betaseed hybrids													
2VK0305	√	√		8/04	10903	91.3	37.89	14.40	152	0.0	95.7	313	2.4
0VK6280		√		8/04	9540	87.9	35.62	13.40	154	0.0	94.6	291	2.1
2AP0852	√		√	8/04	12415	91.3	40.66	15.28	160	0.4	96.9	406	1.5
2EN5066			√	8/04	12090	93.3	39.63	15.24	162	0.0	95.9	254	1.9
USDA breeding lines													
N412(Sp)(CN12)	√		√	N212-#(C), N312aa x A	8478	86.0	33.62	12.61	154	1.8	95.4	384	1.3
N472(Sp)(CN72)	√		√	N272-#(C), N372aa x A	6158	60.6	28.23	10.94	152	9.4	93.4	659	2.8
Y475	√		√	RZM-ER-% Y275	8129	80.6	31.23	13.03	153	1.1	95.5	401	2.4
USDA experimental hybrids													
N412H5	√		√	C833-5HO x N212-#(C)	8264	74.1	29.21	14.17	156	0.0	94.4	236	1.8
N472H5	√		√	C833-5HO x N272-#(C)	8823	70.5	33.24	13.27	153	0.2	95.3	365	2.5
1927-4H5	√		√	C833-5HO x RZM 9927-4	8600	68.7	30.61	14.08	151	0.0	94.8	234	2.1
4927-202H50	√		√	C790-15CMS x 2927-4-202	11160	88.3	37.60	14.83	155	0.0	95.0	226	1.1

TEST B505. HYBRIDS WITH COMBINED RESISTANCE TO SBCN & RZM FROM VARIOUS SOURCES, IMPERIAL VALLEY, CA, 2004-2005
(cont.)

Variety	Resistance Rz	Resistance NR1	Resistance NR2	Description	Acre Yield Sugar Lbs	Acre Yield Relative SY(%)	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N ppm	Canopy score
USDA experimental hybrids (cont.)													
Y491H93	+	√		N365-31HO x Y391	6075	54.3	23.73	12.78	140	0.3	95.6	347	2.3
N412-202H5	√		√	C833-5HO x N212-202	10235	76.2	34.58	14.79	151	0.0	93.0	231	2.4
N472-233H5	√		√	C833-5HO x N272-233	9481	71.6	40.22	11.81	150	0.2	96.3	600	1.8
4926-11-3-22H5	√		√	C833-5HO x 2926-11-1-3	10594	78.5	34.44	15.40	152	0.0	96.0	123	1.4
Mean					8880.6		31.83	13.94	153.8	0.7	95.2	312.6	2.4
LSD (.05)					929.6		2.97	0.56	8.0	1.3	1.0	61.0	0.5
C.V. (%)					10.6		9.49	4.04	5.3	199.9	1.1	19.8	20.1
F value					30.2**		28.58**	34.50**	2.5**	17.3**	9.3**	31.0**	18.4**

Rz = Holly (Rz1) or other sources of resistance to rhizomania.
NR1 = *B.procumbens* source of nematode resistance.
NR2 = Possible other sources of nematode resistance or tolerance.

See test B205 for relative nondiseased conditions.

N412(Sp) and N472(Sp) were released in early 2005 as CN12 and CN72. 1927-4 = C927-4. 4927-202 was selected for nematode resistance from C927-4 and may be released as CN927-202 in 2005. 4926-11-3-22 may be released as CN926-11-3-22. Lines N412, N472, Y475, C927-4, 2927-202, N212-202, N272-233, and 2926-11-1-3 were chosen for testing because of their performance in tests in Imperial Valley under the pressure of high temperatures, SBCN, and rhizomania. They may or may not have resistance to SBCN. Line N365-31HO segregates for resistance to SBCN from *B.procumbens*.

Canopy score = appearance score (= beauty score): rating of canopy prior to harvest. Scored at harvest, where 1 = best and 5 = worst. 1 = estimate of how canopy (size, color, vigor, wilting, chlorosis, necrosis, survival, etc.) would look in absence of disease (SBCN & rhizomania). 5 = plants stunted, dead, dying and in very poor general health and appearance. 3 = approximately how lines with only *Rz* factor would rate.

Tests B405-B705 were grown in Field K on the Imperial Valley Research Center, Brawley. This section of Field K is known to have very high initial populations of cyst nematode, *Heterodera schachtii*. The effects of rhizomania appear to be relatively less and only mild. Sugar samples were run by Spreckels Sugar Co., Imperial Sugar Inc., Brawley.

TEST B505. HYBRIDS WITH COMBINED RESISTANCE TO SBCN & RZM FROM VARIOUS SOURCES, IMPERIAL VALLEY, CA, 2004-2005
(cont.)

SUGARBEET CYST NEMATODE SOIL COUNTS

Variety	Resistance			Description	Cysts Empty		Cysts Full/Viable		No. Eggs & Larvae	
	Rz	NR1	NR2		1/25/05	6/06/05	1/25/05	6/06/05	1/25/05	6/06/05
Beta 4430R	√			RZM resist ck, 8/21/03	154	210	41	42	4746	4846
Phoenix	√			Commercial ck, 9/12/03	190	231	52	46	7989	5516
Hil-2	√	√		8/04	174	191	19	13	1181	911
HXN1	√	√		9/7/04	178	201	23	31	3520	2872
HXN2	√		√	9/7/04	174	245	30	41	3764	3200
2VK0305	√	√		8/04	151	156	14	17	1245	1449
2AP0852	√		√	8/04	197	197	20	26	1737	1812
N412 (CN12)	√		√		177	212	30	36	2866	2458
N472 (CN72)	√		√		186	227	33	42	3827	3363
4927-202H50	√		√		171	214	34	38	3441	3526
Mean					175.3	208.2	29.5	33.2	3431.7	2995.2
LSD (.05)					36.5	31.2	8.9	8.7	1347.9	1097.9
C.V. (%)					20.8	15.0	30.2	26.2	39.3	36.7
F value					1.3NS	5.0**	13.1**	13.1**	17.5**	13.8 **

10 varieties sampled on January 25, 2005 and again on June 6, 2005 at harvest.

NOTES: Counts for 100 grams soil. Soil cores taken to 12" deep, 8 cores/plot composited per plot, 3-4 inches from plants. Initial samples at planting 9/15/04 or before not taken. From the soil samples used to count cyst nematode, tests were run in the greenhouse to determine if there was BNYVV (rhizomania) in these trials. Based upon the ELISA results of the baited plants. Fields J and K at Brawley do not have rhizomania. Also, BOLV was not present.

TEST B605. PERFORMANCE OF LINES WITH RESISTANCE TO SBCN AND RHIZOMANIA, IMPERIAL VALLEY, CA, 2004-2005

48 entries x 6 reps., RCB
1-row plots, 18 ft. long

Planted: September 15, 2004
Harvested: June 6, 2005

Variety	Resistance	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N ppm	Canopy score
Checks										
Phoenix	*Rz*	Rhizomania resist. check	5167	20.17	12.80	162	0.0	95.6	352	3.7
Beta 4430R	*Rz*	Rhizomania resist. check	8010	26.76	15.02	152	0.0	96.9	250	2.8
Angelina	*Rz1*,*Rz2*	Rhizomania resist. check	6725	25.02	13.45	156	0.0	93.1	262	2.7
Roberta	--	Rhizomania susc. check	8091	27.01	15.06	148	0.0	96.0	213	2.3
US H11	--	Susc. check	3979	15.89	12.58	160	0.0	92.1	289	3.3
1927-4H5	*Rz*,R22	C833-5HO x RZM 9927-4	9205	34.16	13.49	155	0.0	96.2	317	2.0
Multigerm breeding lines & hybrids										
N412(Sp)(CN12)	*Rz*, WB242	N212-#(C), N312aa x A	7768	30.87	12.50	148	0.0	95.7	423	2.0
N412H5	*Rz*, WB242	2833-5HO x N212-#(C)	7061	25.44	13.92	156	1.2	95.5	255	2.0
N472(Sp)(CN72)	*Rz*, *Bvm*	N272-#(C), N372aa x A	5326	27.46	9.76	158	8.4	95.9	982	2.5
N472H5	*Rz*, *Bvm*	2833-5HO x N272-#(C)	8276	31.98	13.01	160	0.6	96.2	454	2.3
N412(Iso)	*Rz*, WB242	PMR-RZM N312 (A,aa)	6212	25.72	12.10	153	0.6	94.7	407	2.2
N472(Iso)	*Rz*, *Bvm*	RZM-NR N372 (A,aa)	7067	28.75	12.41	158	3.9	94.6	585	2.2
Multigerm breeding lines										
P427	*Rz*, WB97	PMR-RZM P327 (CP03)	3151	12.16	12.97	154	0.0	93.8	235	3.7
P428	*Rz*, WB242	PMR-RZM P328 (CP04)	7067	31.41	11.21	152	0.0	95.3	406	1.0
P429	*Rz*, WB97	PMR-RZM P329 (CP05)	4967	18.39	13.53	159	0.0	95.0	228	3.3
P430	*Rz*, WB242	PMR-RZM P330 (CP06)	5773	21.48	13.56	143	0.0	94.7	273	2.7
P418-6	*Rz*,WB242	PMR-RZM P318-6 (CP08)	6532	23.56	13.85	149	0.0	92.0	238	2.0
P407/8	*Rz*,WB242,R22	PMR-RZM-% P207/8 (CP07)	8221	29.22	14.07	157	0.0	96.5	241	1.2
04-C37	--	Inc. 03-C37	2481	9.38	13.09	146	0.0	91.9	184	4.2
R378(C78/3)	*Rz*	RZM-ER-% R178	4888	17.70	13.78	161	1.1	92.1	240	3.3
Y475	*Rz*, R22	RZM-ER-% Y275	7879	29.78	13.13	158	1.1	95.2	388	2.0
Y477	*Rz*, R22	RZM-ER-% Y277	6757	26.83	12.84	153	1.6	97.2	446	2.3
R421	*Rz*, *Bvm*	RZM-ER-% R221	6340	24.99	12.72	158	0.0	94.2	412	2.2
Y492	*Rz*, R22	RZM-ER-% Y292	5496	19.15	14.53	152	0.0	93.7	300	2.7
P431CT	*Rz*, WB242	RZM, CTR R278, P230, P207/8	5203	19.12	13.62	156	0.0	94.2	279	2.0
R481-22	*Rz*	RZM R181-22, (C81-22)	4248	16.57	12.88	151	0.0	95.3	324	3.0

TEST B605. PERFORMANCE OF LINES WITH RESISTANCE TO SBCN AND RHIZOMANIA, IMPERIAL VALLEY, CA, 2004-2005
(cont.)

Variety	Resistance	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N ppm	Canopy score
Multigerm breeding lines (cont.)										
R480-6	*Rz*	RZM R280-6	5197	18.26	14.25	156	0.0	94.5	192	3.3
Y467-21	*Rz*, R22	RZM Y267-21	6699	24.39	13.81	148	0.0	96.3	270	2.3
Y471-14	*Rz*, R22	RZM Y271-14	6374	20.91	15.37	152	0.0	95.1	189	3.2
R443-14	*Rz*, R22	RZM R243-14	6142	22.55	13.72	158	0.0	94.5	277	2.7
Checks for Progeny lines in progeny tests										
4926-11-1-3	*Rz*, R22	Inc. 2926-11-1-3	6264	23.07	13.51	151	1.3	95.9	142	2.3
4926-11-3-22	*Rz*, R22	Inc. 2926-11-3-22,(CN926-11-3-22)	7387	24.57	15.08	160	0.0	97.3	136	2.0
4926-11-7-61	*Rz*, R22	Inc. 2926-11-7-61	6440	20.00	16.09	166	0.0	95.2	134	2.2
4926-11-10-91	*Rz*, R22	Inc. 2926-11-10-91	6501	21.36	15.26	153	0.0	96.2	232	2.3
4927-202	*Rz*, R22	Inc. 2927-4-202,(CN927-202)	8373	29.98	13.95	151	0.0	95.8	206	1.5
3927-4	*Rz*, R22	RZM 2927-4(A,aa)	7210	26.65	13.59	158	0.0	97.0	377	2.3
4931(C931)	*Rz*	3931aa x A	4433	16.78	13.54	158	1.2	92.6	274	2.8
R336(C79-8)	R22	RZM-ER-% R136, (C79-8)	6599	26.96	12.16	147	0.0	93.5	461	1.8
04-C37	--	Inc. 03-C37	1866	6.94	13.39	158	0.0	89.8	135	4.2
4747	--	Inc. 0747 (A,aa)	3095	12.72	12.28	142	0.0	91.0	307	3.7
4921	*Rz*,R22,*Bvm*	RZM-ER-% 2921 (A,aa)	4596	17.94	12.87	140	0.0	94.9	363	3.3
0926	*Rz*, R22	RZM-% 8926(Sp)	6511	25.00	13.13	162	0.0	93.5	338	2.2
Selected lines from CN12 & CN72										
N412-6	*Rz*, WB242	Inc. N212-6	5912	20.49	14.32	150	1.2	90.2	230	1.3
N412-10	*Rz*, WB242	Inc. N212-10	7096	24.34	14.58	160	0.0	96.9	150	3.7
N412-13	*Rz*, WB242	Inc. N212-13 (susc. Check)	455	2.19	10.77	159	0.0	86.5	221	4.3
N412-203	*Rz*, WB242	Inc. N212-203	4281	18.46	11.69	147	1.2	92.9	614	1.8
N472-231	*Rz*, *Bvm*	Inc. N272-231	4855	26.40	9.32	148	19.9	95.0	817	2.8
N472-233	*Rz*, *Bvm*	Inc. N272-233	4675	29.06	7.97	145	0.0	96.5	287	2.0
Mean			5892.7	22.46	13.18	153.8	0.9	94.5	340.3	2.6
LSD (.05)			1508.3	5.51	1.08	18.8	3.3	2.3	101.9	0.7
C.V. (%)			22.5	21.58	7.22	10.7	321.0	2.1	26.3	23.0
F value			11.0**	11.28**	15.47**	0.8NS	6.9**	7.1**	34.7**	10.5**

TEST B605. PERFORMANCE OF LINES WITH RESISTANCE TO SBCN AND RHIZOMANIA, IMPERIAL VALLEY, CA, 2004-2005
(cont.)

Variety	Resistance	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Beets/ 100'	Bolters	Clean Beets	NO3-N	Canopy
			Lbs	Tons	%	No.	%	%	ppm	score

Notes: Soil core samples were taken on 1/25/05 for variety Beta 4430R and averaged 6250 nematode eggs & larvae/100 grams soil. On 6/4/05, soil cores were taken from varieties Beta 4430R, 4926-11-3-22 (CN926-11-3-22), 4927-202 (CN927-202), 04-C37, N472-233, and N412-6 and averaged 6325, 1943, 2422, 5054, 3118, and 3612 eggs+larvae/100g.

MM lines undergoing improvement and development at Salinas. Sources of resistance: *Rz* = *Rz1*. *Rz2* = WB42. R22 = C50,C51 releases with *Bvm* background. *Bp* = nematode resistance from *B.procumbens*. WB242 = *Bvm* and possible source of resistance to PM and SBCN. WB97 = possible PMR source. WB41,42,151 accessed from Denmark. 1927-1 & 3927-4 = C927-4. N412(Sp) = CN12. N472(Sp) = CN72. 4926-11-3-22 = CN926-11-3-22. 4927-202 = CN927-202. N412-13 is susc. to SBCN according to greenhouse tests. N412-6,-10,-203 segregate for SBCN resistance form WB242. N472-231 & -233 have SBCN resistance from *Bvm*.

Canopy score = Appearance score. See Test B505.

Notes: From the soil samples used to count cyst nematode, tests were run in the greenhouse to determine if there was BNYVV (rhizomania) in these trials. Based upon the ELISA results of the baited plants. Fields J and K at Brawley do not have rhizomania. Also, BOLV was not present.

TEST B1105. OBSERVATION TEST OF LINES FOR APPEARANCE IN IMPERIAL VALLEY UNDER SEVERE SBCN, RHIZOMANIA, & HIGH TEMPERATURE CONDITIONS, IMPERIAL VALLEY, 2004-2005

64 entries x 4 reps., sequential
1-row plots, 14 ft. long

Not harvested for yield
Planted: September 15, 2004

Variety	Resistance	Description	Stand Count	Bolting	Beets/ 100'	Canopy Score	No. Eggs + Larvae	
			No.	%	No.	No.	1/25/05	6/06/05
Checks								
Phoenix	Rz1	Commercial check, 9/12/03	23.0	0.0	164	3.5		
Beta 4430R	Rz1	Commercial check, 8/21/03	23.8	0.0	170	3.0	8494	8401
Rizor	SES	check, 3/30/01	21.8	0.0	155	3.0		
HXN1	NR1	9/7/04	20.0	0.0	143	2.8		
HXN2	NR2	9/7/04	21.3	0.0	152	3.3		
US H11	---	susc. check	21.3	0.0	152	3.3	16996	15929
Hil-3	Bp	4/22/03	22.0	0.0	157	3.0		
2EN5066	NR2	9/12/03	21.8	0.0	155	1.5		
3927-4H50	R22	C790-15CMS x 2927-4 (C927-4)	23.5	0.0	168	1.5		
04-C37	---	Inc. 03-C37	21.5	0.0	154	4.8		
R336	R22	RZM-ER-% R136, (C79-8)	22.5	0.0	161	2.8		
Angelina	Rz1,Rz2	check, 2/25/04	21.5	0.0	154	3.3		
Rhizomania resistance from *Bvm*								
R425	*Rz2*, WB42	RZM-% R725, R325 (C79-3)	20.8	0.0	148	3.0		
R424	*Rz3*, *WB41*	RZM-% R724, R324 (C79-2)	19.8	0.0	141	3.5		
R424/5	*Rz2*	RZM-% R824, R324/5	20.5	0.0	146	3.0		
R437	WB151	RZM-% R637, R337 (C79-9)	19.0	0.0	136	3.5		
Multigerm breeding lines								
Y475	Rz1,R22	RZM-ER-% Y275	21.3	0.0	152	2.5		
Y477	Rz1,R22	RZM-ER-% Y277	22.0	2.3	157	3.3		
R421	Rz1,*Bvm*,R22	RZM-ER-% R221	22.5	0.0	161	2.5		
4921	Rz1,*Bvm*,R22	RZM-ER-% 2921(A,aa)	20.0	0.0	143	3.8		
Y467-21	R22	RZM Y267-21	20.8	1.1	148	3.0		
Y471-14	R22	RZM Y271-14	21.3	0.0	152	3.8		

TEST B1105. OBSERVATION TEST OF LINES FOR APPEARANCE IN IMPERIAL VALLEY UNDER SEVERE SBCN, RHIZOMANIA, & HIGH TEMPERATURE CONDITIONS, IMPERIAL VALLEY, 2004-2005
(cont.)

Variety	Resistance	Description	Stand Count No.	Bolting %	Beets/ 100' No.	Canopy Score No.	No. Eggs + Larvae 1/25/05	No. Eggs + Larvae 6/06/05
Multigerm breeding lines (cont.)								
R443-14	R22	RZM R243-14	21.3	0.0	152	2.5		
Y492	Rz1,R22	RZM-ER-% Y292	21.3	0.0	152	2.8		
PMR & SBCNR lines (?)								
P427	Rz1,WB97	PMR-RZM P327, (CP03)	22.0	0.0	157	4.3		
R428	Rz1,WB242	PMR-RZM P328, (CP04)	22.8	2.2	162	1.3		
P429	Rz1,WB97	PMR-RZM P329, (CP05)	20.8	0.0	148	3.8		
P430	Rz1,WB242	PMR-RZM P330, (CP06)	21.5	0.0	154	4.0		
R378(Iso)	Rz1	RZM-ER-% R178, (C78/3)	21.0	1.3	150	3.5		
P418-6	Rz1,WB242	PMR-RZM P318-6, (CP08)	22.5	0.0	161	1.8		
P407/8	Rz1,WB242,R22	PMR-RZM-% P207/8, (CP07)	20.5	0.0	146	1.3		
P431CT	Rz1,WB242,R22	RZM-CTR R278,P230,P207/8	21.3	1.2	152	2.3		
Lines selected from WB242, *Bvm* (NR2), & R22 sources (CN12,CN72,CN926,CN927)								
N412-6	Rz1,WB242	Inc. N212-6	21.3	2.6	152	1.8	--	6728
N412-10	Rz1,WB242	Inc. N212-10	21.3	0.0	152	3.5	--	3546
N412-11	Rz1,WB242	Inc. N212-11	22.0	0.0	157	2.5	--	1714
N412-13	Rz1,WB242	Inc. N212-13, (SBCN susc.)	21.3	0.0	152	4.8	--	11595
N412-202	Rz1,WB242	Inc. N212-202	22.8	0.0	162	3.3	--	4205
N412-203	Rz1,WB242	Inc. N212-203	22.0	1.2	157	2.0	--	2882
N412-205	Rz1,WB242	Inc. N212-205	18.3	1.1	130	2.3	--	4080
N412(Sp)	Rz1,WB242	N212-#(C),N312aa x A,(CN12)	21.0	3.5	150	1.8	--	3941
N472(Sp)	Rz1,NR2	N272-#(C),N372aa x A,(CN72)	21.5	9.1	154	2.8	--	5256
N472-230	Rz1,NR2	Inc. N272-230	22.3	1.2	159	3.3	--	2184
N472-231	Rz1,NR2	Inc. N272-231	20.8	11.2	148	3.8	--	2536
N472-233	Rz1,NR2	Inc. N272-233	20.3	1.1	145	2.8	--	2376
4931	Rz1	3931aa x A, (C931)	19.5	0.0	139	3.8	--	12962
4927-202	R22	Inc. 2927-4-202 (CN927-202)	22.0	0.0	157	2.3	--	2276

TEST B1105. OBSERVATION TEST OF LINES FOR APPEARANCE IN IMPERIAL VALLEY UNDER SEVERE SBCN, RHIZOMANIA, & HIGH TEMPERATURE CONDITIONS, IMPERIAL VALLEY, 2004-2005
(cont.)

Variety	Resistance	Description	Stand Count	Bolting	Beets/ 100'	Canopy Score	No. Eggs + Larvae 1/25/05	No. Eggs + Larvae 6/06/05
			No.	%	No.	No.		
Lines selected from WB242, *Bvm* (NR2), & R22 sources (CN12,CN72,CN926,CN927) (cont.)								
3927-4	R22	RZM 2927-4 (A,aa) (C927-4)	22.0	0.0	157	2.3	--	4198
4926-11-1-3	R22,Rz1	Inc. 2926-11-1-3	19.8	1.3	141	2.3	--	5750
4926-11-3-22	R22,Rz1	Inc. 2926-11-3-22 (CN926-11-3-22)	23.0	0.0	164	2.5	--	1365
4926-11-7-61	R22,Rz1	Inc. 2926-11-7-61	24.3	0.0	173	2.5	--	5781
4926-11-10-91	R22,Rz1	Inc. 2926-11-10-91	20.8	0.0	148	2.5	--	3641
4747	---	Inc. 0747 (A,aa)	20.0	0.0	143	4.3	20072	17893
Hybrids with *B.procumbens* from female								
Y491H5	Rz1	C833-5HO x Y391	20.0	0.0	143	3.3		
Y491H95	Rz1,Bp	N365HO(g) x Y391	21.3	0.0	152	3.3		
Y491H93	Rz1,Bp	N365-31HO(g) x Y391	21.3	0.0	152	2.5		
Y491H94	Rz1,Bp	N365-9HO(g) x Y391	22.0	0.0	157	2.3		
Lines with *B.procumbens* source of resistance								
N424	Rz1,Bp	RZM N324-#(C)(g)(A,aa)	20.0	0.0	143	3.3		
N469m	Rz1,Bp	RZM N369(g)	22.8	0.0	162	3.5		
N465-31-1m	Rz1,Bp	RZM N365-31(g)(1 lg plant)	20.8	0.0	148	3.0		
4848m	Rz1,R22	RZM-% 2848 (A,aa)	21.5	0.0	154	4.8		
Lines with root knot nematode resistance								
04-C37	---	Inc. 03-C37	21.0	0.0	150	3.8		
K402	Rz1,RKN	RKNR M6-2 (homoz. resist.)	20.0	0.0	143	4.0		
K403	Rz1,RKN	RKNR M1-3,-3a	20.8	0.0	148	3.8		
K404	Rz1,RKN	RKNR M1-4	17.5	0.0	125	3.5		
Mean			21.3	0.6	151.8	3.0		
LSD (.05)			3.6	2.7	25.9	0.9		
C.V. (%)			12.3	304.9	12.3	21.3		
F value			0.9NS	3.8**	0.9NS	6.6**		

TEST B1105. OBSERVATION TEST OF LINES FOR APPEARANCE IN IMPERIAL VALLEY UNDER SEVERE SBCN, RHIZOMANIA, & HIGH TEMPERATURE CONDITIONS, IMPERIAL VALLEY, 2004-2005
(cont.)

Variety	Resistance	Description	Stand Count	Bolting	Beets/ 100'	Canopy Score	No. Eggs + Larvae	
			No.	%	No.	No.	1/25/05	6/06/05

NOTES: See Tests B505, B605, and B705.

Canopy was scored (6/3/05) from 1 to 5 where 1 = normal and 5 = severe to dead (see Tests B505, B605, & B905).

P431CT recombines plants from C78/3, CP06, & CP07 that were selected from a trial at Dos Palos, CA that had severe rhizomania, curly top, and root rot. It segregates for *Pm*, *Rz1*, and resistance to SBCN from WB242 and R22. Test B1105 suggested 1/4 to 1/3 of the plants were resistant to SBCN based on canopy vigor and color. The increase of P431CT may be released as CP09CT in 2005.

From the soil samples used to count cyst nematode, tests were run in the greenhouse to determine if there was BNYVV (rhizomania) in these trials. Based upon the ELISA results of the baited plants, Fields J and K at Brawley do not have rhizomania. Also, BOLV was not present.

TEST B705. PROGENY PERFORMANCE UNDER SBCN AND RHIZOMANIA, IMPERIAL VALLEY, CA, 2004-2005

96 entries x 2 reps., sequential
1-row plots, 18 ft. long

Planted: September 15, 2004
Harvested: June 6, 2005

Variety	Resistance	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Beets/ 100'	Bolters	Clean Beets	NO3-N	Canopy
			Lbs	Tons	%	No.	%	%	ppm	score
Checks										
Beta 4430R	Rz	Resist. Rz check	7541	25.41	14.86	161	0.0	95.6	265	3.5
Phoenix	Rz	Resist. Rz check	7480	31.91	11.90	167	0.0	95.3	390	3.5
US H11	--	Susc. check	3647	15.34	11.93	150	0.0	91.9	464	3.5
Roberta	--	Susc. check	7362	24.18	15.06	150	0.0	93.6	268	3.5
1927-4H5	Rz, R22	C833-5HO x RZM 9927-4	9563	36.09	13.24	175	0.0	95.0	274	2.0
P418-6(CP08)	Rz,WB242	PMR-RZM P318-6(Iso)	7507	28.14	13.31	147	0.0	94.4	336	2.5
P407/8(CP07)	Rz, WB242,R22	PMR-RZM-% P207/8	7241	26.92	13.39	147	0.0	96.0	265	2.0
Y475	Rz, R22	RZM-ER-% Y275	6420	23.30	13.81	170	0.0	94.4	445	2.0
N412(Sp)(CN12)	WB242	N212-#(C), N312aa x A	9145	33.06	13.82	147	3.8	94.9	238	2.0
N412(Iso)	WB242	PMR-RZM N312 (A,aa)	7973	30.52	13.13	161	0.0	94.8	305	1.5
N412-6	WB242	Inc. N212-6	4497	15.28	14.69	142	3.6	89.0	185	1.5
N412-10	WB242	Inc. N212-10	5677	19.31	14.60	156	0.0	96.3	113	3.5
N412-11	WB242	Inc. N212-11	6486	27.93	11.68	147	0.0	93.2	311	3.0
N412-13	WB242	Inc. N212-13,SBCN susc check	336	2.05	8.22	133	0.0	79.9	464	4.0
N412-202	WB242	Inc. N212-202	7379	28.66	12.73	142	0.0	87.2	241	3.0
N412-203	WB242	Inc. N212-203	3963	16.73	11.80	164	0.0	91.9	682	1.5
N412-205	WB242	Inc. N212-205	4553	17.59	12.94	139	0.0	95.8	314	2.5
N472(Sp)(CN12)	Bvm	N272-#(C), N372aa x A	8192	33.65	12.08	147	0.0	91.9	536	2.5
N472(Iso)	Bvm	RZM-NR N372 (A,aa)	5531	24.09	11.51	150	2.1	93.6	587	3.0
N472-230	Bvm	Inc. N272-230	3433	15.70	10.92	150	3.7	88.9	480	3.0
N472-231	Bvm	Inc. N272-231	5960	28.97	10.27	167	20.0	95.0	625	3.5
N472-233	Bvm	Inc. N272-233	5508	33.86	8.14	136	0.0	96.5	1317	2.5
4927-202	Rz, R22	Inc. 2927-4-202(CN927-202)	7349	25.89	14.13	150	0.0	95.2	144	3.0
US H11	--	Susc. check	4160	17.47	11.92	164	0.0	93.5	387	3.5

TEST B705. PROGENY PERFORMANCE UNDER SBCN AND RHIZOMANIA, IMPERIAL VALLEY, CA, 2004-2005 (cont.)

Variety		Resistance	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Beets/ 100'	Bolters	Clean Beets	NO3-N	Canopy
				Lbs	Tons	%	No.	%	%	ppm	score
Checks (cont.)											
N412-11H5		*Rz*, WB242	2833-5HO x N212-11	11330	37.58	15.08	114	0.0	95.6	197	2.5
N412-13H5		*Rz*, WB242	2833-5HO x N212-13	5748	21.32	13.68	153	0.0	89.8	277	2.5
N412-202H5		*Rz*, WB242	2833-5HO x N212-202	8551	28.81	14.83	156	0.0	93.2	214	1.5
N412-203H5		*Rz*, WB242	2833-5HO x N212-203	8362	30.86	13.56	136	0.0	92.4	364	1.5
N412-205H5		*Rz*, WB242	2833-5HO x N212-205	6663	23.42	14.16	156	0.0	95.9	305	3.0
N472-230H5		*Rz*, *Bvm*	2833-5HO x N272-230	10468	39.76	13.21	139	0.0	96.2	389	2.5
N472-231H5		*Rz*, *Bvm*	2833-5HO x N272-231	6004	22.01	13.63	75	0.0	94.3	206	4.5
N472-233H5		*Rz*, *Bvm*	2833-5HO x N272-233	8204	37.10	10.91	147	0.0	96.9	735	2.0
S_3 or S_n lines from N12											
N412-2	-401	WB242	N212-2⊗	2313	11.18	10.44	114	73.5	95.5	470	4.0
	-402			3418	17.88	9.76	117	84.1	95.1	660	3.5
	-403			2582	14.10	9.33	122	86.4	96.3	606	4.0
	-404			3171	15.16	10.46	139	90.0	95.3	487	3.5
N412-8	-407	WB242	N212-8⊗	2858	10.91	13.10	100	0.0	95.6	332	3.5
	-408			5808	21.76	13.34	111	0.0	96.7	622	2.0
	-409			3232	13.44	12.03	100	0.0	96.1	509	4.0
	-410			2882	12.79	11.26	111	0.0	95.1	664	3.5
N412-17	-415	WB242	N212-17⊗	7180	26.66	13.45	136	0.0	96.8	270	3.0
	-416			7706	29.48	13.13	128	0.0	97.0	363	3.0
	-417			6538	25.55	12.86	117	2.6	97.3	379	3.5
	-418			6152	25.05	12.36	122	0.0	97.1	314	3.5
N412-19	-423	WB242	N212-19⊗	2676	9.47	15.11	114	0.0	89.3	208	4.0
	-424			5214	17.49	15.26	114	0.0	91.8	244	4.0
	-425			3591	11.33	15.90	97	0.0	94.1	191	3.0
	-426			2947	9.80	15.32	106	0.0	93.4	190	3.0

TEST B705. PROGENY PERFORMANCE UNDER SBCN AND RHIZOMANIA, IMPERIAL VALLEY, CA, 2004-2005 (cont.)

Variety	Resistance	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N ppm	Canopy score
S_3 or S_n lines from N12 (cont.)										
N412-22 -431	WB242	N212-22⊗	2939	13.12	10.96	136	0.0	95.4	253	3.5
-432			6347	27.30	11.82	147	0.0	93.7	276	3.0
-433			2973	12.78	11.67	139	0.0	90.7	269	3.0
-434			2996	12.94	11.58	125	0.0	89.1	188	3.0
N412-201 -438	WB242	N212-201⊗	7553	28.68	13.07	136	0.0	93.0	501	2.0
-439			7541	27.20	13.88	114	0.0	96.5	334	2.5
-440			6158	27.68	11.18	114	0.0	93.4	623	2.5
-441			6713	28.79	11.80	142	4.0	96.9	635	2.5
N412-204 -446	WB242	N212-204⊗	7382	28.46	12.99	139	0.0	98.2	442	1.5
-447			6210	23.78	13.01	125	0.0	97.1	458	2.0
-448			6507	25.34	12.80	89	0.0	98.1	448	1.5
-449			6690	24.33	13.75	108	0.0	97.7	199	2.0
N412-206 -452	WB242	N212-206⊗	4625	22.36	10.41	133	0.0	97.3	705	2.5
-453			2937	13.85	10.85	128	0.0	94.9	498	4.5
-454			8621	37.83	11.34	133	1.9	98.2	655	3.0
-455			6708	29.01	11.46	145	0.0	97.5	810	3.0
N412-207 -459	WB242	N212-207⊗	2803	13.30	10.61	108	0.0	93.2	579	3.0
-460			5794	22.89	12.53	92	35.2	97.7	418	3.0
-461			3306	14.03	11.71	72	0.0	96.3	483	3.0
-462			5741	20.16	14.15	95	29.4	96.6	281	2.5
S_3 or S_n lines from N72										
Checks										
N412(Sp)	WB242	N312aa x A, CN12)	10318	37.75	13.66	139	0.0	95.7	359	2.5
N412(Iso)	WB242	PMR-RZM N312 (A,aa)	5527	20.84	13.15	145	0.0	94.7	312	2.0
N472(Sp)	*Bvm*	N272-#(C)aa x A, (CN72)	4033	27.72	7.29	150	18.7	93.8	1167	2.0
N472(Iso)	*Bvm*	RZM-NR N372 (A,aa)	5419	21.49	12.59	175	4.5	94.5	473	3.5

TEST B705. PROGENY PERFORMANCE UNDER SBCN AND RHIZOMANIA, IMPERIAL VALLEY, CA, 2004-2005 (cont.)

Variety		Resistance	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N ppm	Canopy score
S_3 or S_n lines from N72 (cont.)											
Checks (cont.)											
N472-1	-401	*Bvm*	N272-1⊗	3655	16.34	11.32	142	5.8	95.1	670	4.0
	-402			5270	20.25	12.97	133	0.0	90.3	453	3.5
	-403			4212	17.58	12.06	125	0.0	96.3	504	3.5
	-404			4610	19.18	12.01	128	0.0	95.4	720	3.5
N472-2	-409	*Bvm*	N272-2⊗	2807	15.92	8.86	122	0.0	95.5	901	3.0
	-410			3660	18.66	9.82	139	0.0	93.1	769	3.0
	-411			2374	11.93	9.62	125	0.0	95.4	652	3.0
	-412			2276	11.22	10.03	142	0.0	97.3	603	3.0
N472-6	-417	*Bvm*	N272-6⊗	5361	21.95	12.23	125	0.0	96.5	600	3.5
	-418			2794	11.86	11.68	136	0.0	93.5	520	3.5
	-419			4598	20.43	11.14	111	0.0	92.3	826	3.5
	-420			5295	22.85	11.59	108	0.0	96.6	634	3.0
N472-221	-425	*Bvm*	N272-221⊗	8731	40.50	10.82	122	9.1	96.6	828	2.5
	-426			7493	39.70	9.32	128	0.0	98.2	1061	2.5
	-427			8374	42.77	9.80	131	4.3	96.6	754	2.0
	-428			6989	31.84	10.84	131	16.2	98.1	582	2.0
N472-226	-433	*Bvm*	N272-226⊗	2976	17.38	8.60	131	85.4	96.7	425	2.0
	-434			2598	12.97	9.84	122	86.4	92.5	784	2.5
	-435			4367	23.86	9.17	131	68.2	96.7	1089	2.5
	-436			4652	25.71	9.04	131	43.6	95.6	892	3.5
N472-226	-437	*Bvm*	N272-226⊗	4296	26.68	8.05	128	69.6	97.5	859	3.5
N472-227	-441	*Bvm*	N272-227⊗	2570	16.39	7.85	150	0.0	96.8	1348	3.5
	-442			2059	15.15	6.68	142	0.0	96.8	1148	4.5
	-443			1286	8.27	7.75	139	0.0	97.6	1192	4.5

TEST B705. PROGENY PERFORMANCE UNDER SBCN AND RHIZOMANIA, IMPERIAL VALLEY, CA, 2004-2005 (cont.)

Variety	Resistance	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N ppm	Canopy score
Mean			5413.0	22.56	11.89	132.7	8.9	94.8	510.3	2.9
LSD (.05)			2774.6	10.56	1.83	24.3	14.9	3.9	322.7	1.2
C.V. (%)			25.8	23.57	7.75	9.2	84.7	2.1	31.9	21.1
F value			5.3**	5.10**	9.69**	5.7**	18.6**	4.2**	5.6**	3.1**

Notes: 1927-4 = C927-4. 4927-202 = CN927-202. N412-#s are increases of S_2 progenies selected for performance under SBCN conditions; N412-13 was selected for susceptibility and has very high cyst counts in greenhouse tests. N472-#'s are increases of S_2 progenies.

N412-#-# and N472-#-3 are S_3 progenies. S_2 lines of N212-# and N272-# were evaluated in the field at Brawley and Salinas in 2003 for reaction to SBCN, rhizomania, powdery mildew, and performance (see 6503, 1303, & B603). Ten S_2 lines were increased in isolators in 2004. Fifteen lines were increased by selfing individual S_2 plants (shown above in table). Based on performance under SBCN/rhizomania conditions and cyst counts in greenhouse tests, lines with high resistance to SBCN will be selected. With only two replications, test B705 has high variation, but should serve to roughly screen these S_3 progenies.

Canopy score = appearance score (= beauty score): rating of canopy prior to harvest. Scored at harvest, where 1 = best and 5 = worst. 1 = estimate of how canopy (size, color, vigor, wilting, chlorosis, necrosis, survival, etc.) would look in absence of disease (SBCN & rhizomania). 5 = plants stunted, dead, dying and in very poor general health and appearance. 3 = approximately how lines with only *Rz* factor would rate.

See Test B1105 from 2005 for canopy scores of these S_2 lines and others under severe SBCN conditions.

Soil core samples were taken on 1/25/05 for entries Beta 4430R, Roberta, USH11, and N412(Iso) and averaged 10497, 4627, 10580, and 4632 eggs+larvae/100g soil, respectively. On 6/4/05 soil cores were taken from entries Beta 4430R, Roberta, USH11, N412(Iso), N412-6, N412-11, N412-13, N472-231 & N472-233 and averaged 7325, 3582, 8377, 4131, 1725, 3634, 10015, 4466, and 2020 eggs+larvae/100 grams soil, respectively.

From the soil samples used to count cyst nematode, tests were run in the greenhouse to determine if there was BNYVV (rhizomania) in these trials. Based upon the ELISA results of the baited plants, Fields J and K at Brawley do not have rhizomania. Also, BOLV was not present.

TEST B805. PROGENY TEST OF S_2's AND FS's FROM C931, C37, 747 x R36 (C79-8) UNDER SEVERE CONDITIONS, BRAWLEY, CA, 2004-2005.

112 entries x 2 reps., sequential
1-row plots, 14 ft. long

Not harvested for yield
Planted: September 15, 2004

Variety		Description	Stand Count No.	Bolting %	Beets/ 100' No.	Canopy Score No.	No. Eggs + Larvae 1/25/05	No. Eggs + Larvae 6/06/05
Checks								
4931		3931aa x A, (C931)	19.0	2.6	136	3.0	6531	7657
R336		RZM-ER-% R136, (C79-8)	19.0	0.0	136	3.0	5404	12887
04-C37		Inc. 03-C37	19.0	0.0	136	4.0	8070	10134
3927-4		RZM 2927-4 (A,aa)	22.0	0.0	157	2.5	3504	7860
4747		Inc. 0747 (A,aa)	18.0	0.0	129	4.0	5677	9454
R336		RZM-ER-% R136, (C79-8)	19.5	0.0	139	2.5		
4927-202		Inc. 2927-4-202,(C927-202)	18.0	0.0	129	2.0		
S_2's of C931 x R36								
4235-1	-401	2235-1-1⊗	18.5	0.0	132	4.0		
	-402		13.0	0.0	93	5.0		
	-403		15.5	0.0	111	5.0		
4235-1	-407	2235-1-2⊗	18.5	0.0	132	4.0		
	-408		15.5	0.0	111	4.0		
	-409		16.0	0.0	114	5.0		
4235-3	-411	2235-1-3⊗	19.5	0.0	139	3.0		
4235-3	-412	2235-1-3⊗	17.5	0.0	125	3.5		
	-413		12.5	0.0	89	5.0		
	-414		15.0	0.0	107	4.0		
4235-4	-418	2235-1-4⊗	17.5	0.0	125	5.0		
	-419		19.5	0.0	139	4.5		
	-420		16.5	0.0	118	4.0		
4235-5	-423	2235-1-5⊗	15.0	0.0	107	3.0		
4235-5	-424	2235-1-5⊗	21.5	0.0	154	4.0		
	-425		18.5	0.0	132	3.5		
	-426		17.5	0.0	125	4.0		

TEST B805. PROGENY TEST OF S_2's AND FS's FROM C931, C37, 747 x R36 (C79-8) UNDER SEVERE CONDITIONS, BRAWLEY, CA, 2004-2005.
(cont.)

Variety	Description	Stand Count No.	Bolting %	Beets/ 100' No.	Canopy Score No.	No. Eggs + Larvae 1/25/05	No. Eggs + Larvae 6/06/05
S_2's of C931 x R36 (cont.)							
4235-12 -427	2235-2-12⊗	17.5	0.0	125	4.0		
-428		16.5	0.0	118	3.0		
4235-23 -432	2235-3-23⊗	19.0	0.0	136	4.5		
-433		15.5	0.0	111	4.0		
4235-23 -434		18.5	0.0	132	4.0		
-435		18.0	5.6	129	4.0		
-436		17.0	0.0	121	4.5		
4235-31 -439	2235-4-31⊗	17.0	0.0	121	4.0		
-440		17.0	11.8	121	4.5		
-441		17.5	0.0	125	4.5		
Full-sibs of C37 x R36 (FS of FS's)							
4236-21 -401	2236-3-21PX	14.0	0.0	100	3.5		
-402		18.5	0.0	132	3.0		
-403		16.0	0.0	114	3.5		
4236-22 -407		16.5	0.0	118	4.0		
-408		17.5	0.0	125	4.0		
-409		19.0	0.0	136	3.5		
4236-41 -413	2236-5-41PX	19.0	0.0	136	3.5		
-414		19.5	0.0	139	3.0		
-415	2236-5-41PX	21.5	0.0	154	3.5		
-416		18.0	0.0	129	3.0		
-417		18.5	0.0	132	3.0		
4236-42 -418	2236-5-42PX	20.0	0.0	143	4.0		
-419		18.5	0.0	132	4.0		
-420		18.0	0.0	129	3.5		
4236-43 -424	2236-5-43PX	18.0	0.0	129	3.0		
-425		17.5	0.0	125	3.5		

TEST B805. PROGENY TEST OF S_2's AND FS's FROM C931, C37, 747 x R36 (C79-8) UNDER SEVERE CONDITIONS, BRAWLEY, CA, 2004-2005.
(cont.)

Variety		Description	Stand Count	Bolting	Beets/ 100'	Canopy Score	No. Eggs + Larvae	
			No.	%	No.	No.	1/25/05	6/06/05
S_2's of popn-747 x R36								
4237-1	-401	2237-1-1⊗	19.0	0.0	136	3.5		
	-402		17.5	0.0	125	4.0		
	-403		17.5	0.0	125	4.5		
	-404		16.0	0.0	114	4.0		
	-405		17.5	0.0	125	4.5		
4237-2	-407	2237-1-2⊗	18.0	0.0	129	5.0		
4237-2	-408	2237-1-2⊗	17.5	0.0	125	4.0		
	-409		18.5	0.0	132	4.0		
	-410		18.0	0.0	129	4.5		
Checks								
R336		RZM-ER-% R136 (C79-8)	19.5	0.0	139	2.0		
3927-4		RZM 2927-4 (A,aa)	18.5	0.0	132	2.5		
S_2 of popn-747 x R36 (cont.)								
4237-3	-412	2237-1-3⊗	18.0	0.0	129	4.0		
	-413		16.5	0.0	118	4.5		
	-414		19.0	0.0	136	4.0		
4237-4	-416	2237-1-4⊗	22.5	0.0	161	4.0		
	-417		18.5	0.0	132	4.0		
	-418		19.5	0.0	139	4.5		
	-419		17.5	0.0	125	4.0		
4237-5	-421	2237-1-5⊗	19.0	0.0	136	4.5		
	-422		18.5	0.0	132	3.5		
4237-5	-423	2237-1-5⊗	19.0	0.0	136	4.5		
	-424		17.5	0.0	125	4.0		

TEST B805. PROGENY TEST OF S_2's AND FS's FROM C931, C37, 747 x R36 (C79-8) UNDER SEVERE CONDITIONS, BRAWLEY, CA, 2004-2005.
(cont.)

Variety	Description	Stand Count	Bolting	Beets/ 100'	Canopy Score	No. Eggs + Larvae 1/25/05	No. Eggs + Larvae 6/06/05
		No.	%	No.	No.		
S_2 of popn-747 x R36 (cont.)							
4237-6 -427	2237-1-6⊗	17.5	0.0	125	4.5		
-428		17.0	0.0	121	5.0		
-429		20.0	0.0	143	4.0		
-430		19.0	0.0	136	4.0		
4237-13 -433	2237-2-13⊗	19.0	0.0	136	3.5		
4237-13 -434	2237-2-13⊗	16.5	0.0	118	4.0		
-435		19.5	0.0	139	4.0		
-436		17.5	0.0	125	3.5		
-437		17.0	0.0	121	3.5		
-438		17.5	0.0	125	3.5		
4237-14 -440	2237-2-14⊗	21.5	0.0	154	4.0		
-441		17.5	0.0	125	4.0		
4237-14 -442	2237-2-14⊗	19.0	0.0	136	4.0		
-443		19.0	0.0	136	4.0		
4237-22 -445	2237-3-22⊗	18.0	0.0	129	4.0		
-446		17.0	0.0	121	4.5		
-447		16.0	0.0	114	4.5		
4237-23 -449	2237-3-23⊗	21.5	0.0	154	4.5		
-450		20.0	0.0	143	4.5		
4237-23 -451	2237-3-23⊗	19.0	0.0	136	4.0		
-452		20.5	0.0	146	4.5		
4237-31 -454	2237-4-31⊗	21.0	0.0	150	3.5		
-455		20.0	0.0	143	4.5		
-456		18.5	0.0	132	4.0		
-457		19.5	0.0	139	4.0		
-458		19.5	0.0	139	3.5		

TEST B805. PROGENY TEST OF S_2's AND FS's FROM C931, C37, 747 x R36 (C79-8) UNDER SEVERE CONDITIONS, BRAWLEY, CA, 2004-2005.
(cont.)

Variety	Description	Stand Count No.	Bolting %	Beets/ 100' No.	Canopy Score No.	No. Eggs + Larvae 1/25/05	No. Eggs + Larvae 6/06/05
S_2 of popn-747 x R36 (cont.)							
4237-32 -461	2237-4-32⊗	21.5	0.0	154	4.5		
-462		19.5	0.0	139	3.5		
-463		19.0	0.0	136	4.5		
-464		18.5	0.0	132	3.5		
-465		18.5	0.0	132	5.0		
4237-41 -468	2237-5-41⊗	19.5	0.0	139	5.0		
-469		19.5	0.0	139	4.5		
-470	2237-5-41⊗	19.5	0.0	139	4.0		
-471		20.0	0.0	143	4.5		
4237-42 -474	2237-5-42⊗	18.0	0.0	129	3.5		
-475		18.0	0.0	129	4.0		
-476	2237-5-42⊗	17.0	0.0	121	4.0		
-477		18.0	0.0	129	4.0		
-478		19.0	0.0	136	4.5		
Mean		18.2	0.2	130.2	3.9		
LSD (.05)		3.8	3.5	27.0	1.0		
C.V. (%)		10.5	994.7	10.5	12.7		
F value		1.6*	1.0NS	1.6*	3.2**		

NOTES: From the soil samples used to count cyst nematode, tests were run in the greenhouse to determine if there was BNYVV (rhizomania) in these trials. Based upon the ELISA results of the baited plants, Fields J and K at Brawley do not have rhizomania. Also, BOLV was not present.

TEST B905. PROGENY TEST OF P407/8-#'s (CP07) & P418-6-#'s (CP08) UNDER SEVERE CONDITIONS, BRAWLEY, CA, 2004-2005

96 entries x 2 reps., sequential
1-row plots, 14 ft. long

Not harvested for yield
Planted: September 15, 2004

Variety	Description	Stand Count	Bolting	Beets/ 100'	Canopy Score	No. Eggs + Larvae	
		No.	%	No.	No.	1/25/05	6/06/05
Checks							
$N412_{ISO}$	PMR-RZM N312	21.0	0.0	150	2.0		
$N472_{ISO}$	RZM-NR N372	17.0	0.0	121	2.5		
4931	3931aa x A (C931)	17.0	0.0	121	3.5		
US H11	susc. check	17.5	0.0	125	3.5	7538	11302
P407/8	PMR-RZM-% P207/8 (CP07)	18.5	0.0	132	1.0		
P418-6	PMR-RZM P318-6 (CP08)	19.0	0.0	136	2.0		
Phoenix	9/12/03	18.0	0.0	129	3.5		
Roberta	2/25/04	18.0	0.0	129	3.5		
Beta 4430R	8/21/03	17.0	0.0	121	3.5		
Y475	RZM-ER-% Y275	19.0	0.0	136	2.0		
04-C37	Inc. 03-C37	18.0	0.0	129	4.0		
4927-202	Inc. 2927-4-202 (CN927-202)	19.0	0.0	136	1.5		
Pair-crosses (PX) from P07/8 (CP07)							
P407/8 -401	P307/8 PX	18.5	0.0	132	1.0		
-402		18.5	0.0	132	1.5		
-403		21.0	0.0	150	2.0		
-404		19.0	0.0	136	2.5		
-405		18.5	0.0	132	1.5		
-406		18.0	2.8	129	1.5		
-407		19.0	0.0	136	1.0		
-408		18.5	0.0	132	2.5		
-409		20.0	0.0	143	1.5		
-410		16.0	0.0	114	1.0		
-411		17.5	0.0	125	1.5		
-412		19.5	0.0	139	2.5		

TEST B905. PROGENY TEST OF P407/8-#'s (CP07) & P418-6-#'s (CP08) UNDER SEVERE CONDITIONS, BRAWLEY, CA, 2004-2005
(cont.)

Variety	Description	Stand Count	Bolting	Beets/ 100'	Canopy Score	No. Eggs + Larvae	
		No.	%	No.	No.	1/25/05	6/06/05
Pair-crosses (PX) from P07/8 (CP07) (cont.)							
P407/8 -413	P307/8 PX	21.0	0.0	150	1.0		
-414		21.0	0.0	150	1.5		
-415		21.0	0.0	150	2.0		
-416		16.0	0.0	114	2.0		
-417		17.5	0.0	125	2.5		
-418		18.5	0.0	132	2.5		
-419		19.0	0.0	136	1.0		
-420		18.0	0.0	129	1.5		
-421		19.5	0.0	139	1.0		
-422		16.5	0.0	118	1.5		
-423		18.0	0.0	129	4.0		
-424		19.0	0.0	136	1.5		
-425		18.5	0.0	132	1.5		
-426		16.5	0.0	118	3.5		
-427		21.0	0.0	150	2.0		
-428		19.0	0.0	136	2.5		
-429		20.0	0.0	143	3.0		
-430		19.5	0.0	139	2.0		
-431		19.0	0.0	136	1.0		
-432		19.5	0.0	139	4.0		
Checks							
N412(Sp)	N212-#(C), N312aa x A (CN12)	19.0	2.8	136	2.0	4305	3808
N472(Sp)	N272-#(C), N372aa x A (CN72)	16.0	7.7	114	2.5		
P428	PMR-RZM P328 (CP04)	19.5	2.4	139	1.0		
P430	PMR-RZM P330 (CP06)	18.5	0.0	132	3.5	10232	7110

TEST B905. PROGENY TEST OF P407/8-#'s (CP07) & P418-6-#'s (CP08) UNDER SEVERE CONDITIONS,
BRAWLEY, CA, 2004-2005
(cont.)

Variety	Description	Stand Count	Bolting	Beets/ 100'	Canopy Score	No. Eggs + Larvae	
		No.	%	No.	No.	1/25/05	6/06/05
Pair-crosses (PX) from P18-6 (CP08)							
P418-6 -401	P318-6 PX	18.0	0.0	129	2.0		
-402		19.0	0.0	136	2.5		
-403		20.0	0.0	143	1.5		
-404		18.0	0.0	129	1.5		
-405		19.0	0.0	136	3.0		
-406		18.0	0.0	129	1.0		
-407		20.0	0.0	143	1.5		
-408		19.0	0.0	136	1.5		
-409		16.5	0.0	118	1.5		
-410		20.0	0.0	143	2.0		
-411		21.5	0.0	154	4.0		
-412		19.5	0.0	139	1.0		
-413		18.0	0.0	129	1.0		
-414		21.0	0.0	150	1.5		
-415		19.5	0.0	139	3.5		
-416		17.5	0.0	125	1.5		
-417		20.0	0.0	143	3.0		
-418		18.0	0.0	129	2.0		
-419		16.5	0.0	118	2.5		
-420		19.0	0.0	136	2.0		
-421		16.0	0.0	114	1.5		
-422		20.0	0.0	143	2.5		
-423		18.0	0.0	129	3.0		
-424		17.0	0.0	121	1.0		
Pair-crosses (PX) from P18-6 (CP08)							
P418-6 -425	P318-6 PX	17.5	0.0	125	2.0		
-426		18.0	0.0	129	2.0		
-427		18.5	0.0	132	2.0		

TEST B905. PROGENY TEST OF P407/8-#'s (CP07) & P418-6-#'s (CP08) UNDER SEVERE CONDITIONS, BRAWLEY, CA, 2004-2005
(cont.)

Variety	Description	Stand Count	Bolting	Beets/ 100'	Canopy Score	No. Eggs + Larvae	
		No.	%	No.	No.	1/25/05	6/06/05
Pair-crosses (PX) from P18-6 (CP08) (cont.)							
P418-6 -428	P318-6 PX	18.0	0.0	129	3.0		
-429		18.0	0.0	129	2.5		
-430		18.5	0.0	132	1.5		
-431		18.5	0.0	132	3.0		
-432		18.0	0.0	129	2.5		
-433		19.0	0.0	136	2.0		
-434		19.0	0.0	136	2.0		
-435		18.5	0.0	132	3.5		
-436		19.0	0.0	136	2.0		
-437		16.0	0.0	114	2.5		
-438		18.5	0.0	132	1.0		
-439		17.5	0.0	125	4.0		
-440		15.5	0.0	111	2.0		
-441		19.0	0.0	136	2.5	8176	8562
-442		19.0	0.0	136	1.5		
-443		17.5	0.0	125	1.0		
-444		18.0	0.0	129	1.0		
-445		14.5	0.0	104	1.5		
-446		19.0	0.0	136	2.5		
-447		20.0	0.0	143	2.0		
-448		18.5	0.0	132	1.5		
Mean		18.5	0.2	132.1	2.1		
LSD (.05)		4.7	2.6	33.3	1.2		
C.V. (%)		12.7	793.2	12.7	27.4		
F value		0.7NS	1.0NS	0.7NS	4.5**		

TEST B905. PROGENY TEST OF P407/8-#'s (CP07) & P418-6-#'s (CP08) UNDER SEVERE CONDITIONS, BRAWLEY, CA, 2004-2005
(cont.)

Variety	Description	Stand Count	Bolting	Beets/ 100'	Canopy Score	No. Eggs + Larvae	
		No.	%	No.	No.	1/25/05	6/06/05

NOTES: CP07 = P07/8, P407/8 and CP08 = P18-6, P418-6 were released in 2004 partially based on their performance under SBCN/rhizomania conditions at Brawley. This included canopy and survival score under high temperature conditions, vigor, color, resistance to powdery mildew (*Pm*), etc. CP07 and CP04 have a tendency to stay dark green (stay-green) under the conditions of these tests and there is a suggestion of resistance or tolerance to the feeding of *Empoasca*, but this reaction may actually be due to resistance to powdery mildew. Resistance to powdery mildew is conditioned by gene *Pm* from either WB242 or WB97. In addition, resistance to cyst nematode may be from WB242 or R22(C51).

Test B905 with two replications was planted in a small area of Field K at Brawley where pressure from soil-borne diseases is very high. It is now believed that much of this disease is caused by SBCN, which occurs at high populations. This test was not harvested for yield, but only canopy scores were taken as an indication of overall plant health. Canopy was scored (6/2/05) from 1 to 5 where 1 = normal and 5 = severe to dead (see Test B505). It is believed from results from prior tests that the canopy score under the conditions of this test reflect or show reaction to cyst nematode. Tests B905, B805, B1005, and B1105 are screening trials to identify SBCN resistant phenotypes. These same progeny families are being grown at Salinas under rhizomania conditions where they will also be harvested for components of yield and evaluated for resistance to powdery mildew and other traits. These families are also being individually tested for reaction to cyst nematode in greenhouse trials. Based on reaction to SBCN, powdery mildew, rhizomania, yield, etc., families will be selected and individually increased and/or recombined.

CN12 and CN72 occur as two versions from 2004 seed productions. N412(Sp) and N472(Sp) were released as CN12 and CN72. $N412_{ISO}$ and $N472_{ISO}$ were not released and distributed and appear to have lower frequencies of resistance to SBCN.

TEST B1005. PROGENY TEST S_4's FROM POPN-926 FOR DIVERGENT SELECTION FOR REACTION TO RHIZOMANIA, SBCN, & HIGH TEMPERATURE SURVIVAL IN IMPERIAL VALLEY, BRAWLEY, CA, 2004-2005

96 entries x 2 reps., sequential
1-row plots, 14 ft. long

Not harvested for yield
Planted: September 15, 2004

Variety		Description	Stand Count	Bolting	Beets/ 100'	Canopy Score	Uniformity	No. Eggs+Larvae	
			No.	%	No.	No.	Score	1/25/05	6/06/05
Checks									
8926 (Iso)		RZM 7926(A,aa),(Rz1 x R22*gp*)	20.5	0.0	146	3.5	2.0		
0926		RZM-% 8926(Sp),(7931 x 7926)	19.0	0.0	136	3.0	2.5		
4931		3931aa x A, (C931)	20.0	0.0	143	3.5	3.0		
US H11		susc. check	21.5	0.0	154	3.0	2.0	6415	6096
R336		RZM-ER-% R136 (C79-8)	18.0	0.0	129	3.5	1.5	--	11428
04-C37		Inc. 03-C37	21.0	0.0	150	5.0	3.0	--	5969
4926-11-1-3		Inc. 2926-11-1-3	20.0	0.0	143	2.5	1.0	--	3395
4926-11-3-22		Inc. 2926-11-3-22(CN926-11-3-22)	20.0	0.0	143	3.5	1.0	--	678
4926-11-7-61		Inc. 2926-11-7-61	19.0	0.0	136	3.0	1.5	--	5070
4926-11-10-91		Inc. 2926-11-10-91	19.0	0.0	136	3.0	1.0	--	1223
3927-4		RZM 2927-4 (A,aa) (C927-4)	17.5	0.0	125	3.0	1.5	--	3897
4927-202		Inc. 2927-4-202 (C927-202)	20.0	0.0	143	2.0	2.0	--	4172
S_4 progenies from 8926: (2926-11-#-#⊗ = 1926-11-#⊗ = 9926-11⊗ = 8926									
4926-1	-401	2926-11-1-1⊗	18.0	0.0	129	2.0	1.0		
	-402		14.0	0.0	100	2.5	1.5		
	-403		13.5	0.0	96	2.0	2.0		
	-404		11.0	0.0	79	4.0	3.0		
4926-2	-406	2926-11-1-2⊗	14.5	0.0	104	4.5	3.0		
	-407		5.0	0.0	36	5.0	3.0		
4926-2	-408		22.0	0.0	157	4.0	3.0		
	-409		17.0	0.0	121	4.5	2.5		
4926-3	-412	2926-11-1-3⊗	15.5	0.0	111	4.0	2.5		
	-413		15.5	0.0	111	2.5	1.0		
	-414		20.5	0.0	146	2.5	1.0		
	-415		13.5	0.0	96	4.0	3.0		

TEST B1005. PROGENY TEST S_4's FROM POPN-926 FOR DIVERGENT SELECTION FOR REACTION TO RHIZOMANIA, SBCN, & HIGH TEMPERATURE SURVIVAL IN IMPERIAL VALLEY, BRAWLEY, CA, 2004-2005 (cont.)

Variety		Description	Stand Count	Bolting	Beets/ 100'	Canopy Score	Uniformity	No. Eggs+Larvae	
			No.	%	No.	No.	Score	1/25/05	6/06/05
S_4 progenies from 8926: (2926-11-#-#⊗ = 1926-11-#⊗ = 9926-11⊗ = 8926 (cont.)									
4926-11-1-3		Inc. 2926-11-1-3	20.0	2.6	143	2.5	1.5		
4926-4	-416	2926-11-1-4⊗	16.0	0.0	114	3.5	2.5		
	-417		12.5	0.0	89	2.5	1.0		
	-418		13.0	0.0	93	2.5	1.0		
	-419		19.0	0.0	136	2.0	1.0		
4926-21	-423	2926-11-3-21⊗	16.0	0.0	114	3.0	2.0		
4926-21	-424		16.5	0.0	118	3.5	3.0		
	-425		13.0	0.0	93	2.5	1.5		
4926-22	-429	2926-11-3-22⊗	16.0	0.0	114	2.5	1.0		
	-430		18.5	0.0	132	2.0	1.0		
4926-23	-434	2926-11-3-23⊗	17.0	0.0	121	2.0	1.5		
	-435		17.0	0.0	121	2.0	1.0		
4926-24	-436	2926-11-3-23⊗	15.5	0.0	111	2.5	1.0		
	-439	2926-11-3-24⊗	16.5	0.0	118	2.5	1.0		
	-440		17.0	0.0	121	3.0	1.0		
	-441		19.5	0.0	139	2.0	1.0		
4926-31	-446	2926-11-4-31⊗	16.5	0.0	118	5.0	3.0		
	-447		14.0	0.0	100	5.0	3.0		
4926-31	-448		17.0	0.0	121	4.5	3.0		
	-449		18.5	0.0	132	4.5	3.0		
4926-32	-454	2926-11-4-32⊗	14.0	0.0	100	3.5	2.0		
	-455		16.5	0.0	118	5.0	3.0		
	-456		16.5	0.0	118	4.5	2.5		
4926-33	-460	2926-11-4-33⊗	17.0	0.0	121	2.5	1.5		

TEST B1005. PROGENY TEST S_4's FROM POPN-926 FOR DIVERGENT SELECTION FOR REACTION TO RHIZOMANIA, SBCN, & HIGH TEMPERATURE SURVIVAL IN IMPERIAL VALLEY, BRAWLEY, CA, 2004-2005
(cont.)

Variety	Description	Stand Count No.	Bolting %	Beets/ 100' No.	Canopy Score No.	Uniformity Score	No. Eggs+Larvae 1/25/05	No. Eggs+Larvae 6/06/05
S_4 progenies from 8926: (2926-11-#-#⊗ = 1926-11-#⊗ = 9926-11⊗ = 8926 (cont.)								
4926-33 -461		15.0	0.0	107	4.0	3.0		
-462		15.5	0.0	111	5.0	3.0		
-463		12.5	0.0	89	3.0	1.5		
4926-34 -468	2926-11-4-34⊗	10.5	0.0	75	2.5	1.5		
-469		17.5	0.0	125	3.0	1.0		
-470		14.5	0.0	104	2.5	1.5		
4926-34 -471		15.0	0.0	107	4.5	2.5		
4926-41 -476	2926-11-5-41⊗	16.5	0.0	118	2.0	1.0		
-477		18.0	0.0	129	2.5	1.0		
-478		18.5	0.0	132	2.5	1.0		
-479		19.5	0.0	139	2.0	1.0		
-480		16.0	0.0	114	1.5	1.0		
4926-43 -484	2926-11-5-43⊗	16.0	0.0	114	3.0	1.5		
-485		18.0	0.0	129	3.0	1.5		
-486		11.0	0.0	79	2.5	1.0		
-487		15.5	0.0	111	3.0	1.0		
4926-51 -492	2926-11-6-51⊗	19.0	0.0	136	2.5	1.0		
-493		16.5	0.0	118	2.0	1.0		
4926-51 -494	2926-11-6-51⊗	16.5	0.0	118	5.0	3.0		
-495		19.0	0.0	136	2.5	1.0		
4926-11-1-3	Inc. 2926-11-1-3	19.5	0.0	139	2.5	1.0		
4926-11-3-22	Inc. 2926-11-3-22	22.5	0.0	161	3.0	1.0		
4926-11-7-61	Inc. 2926-11-7-61	18.5	0.0	132	2.5	1.5	1680	3823
4926-11-10-91	Inc. 2926-11-10-91	18.5	0.0	132	3.0	1.0		
4926-61 -498	Inc. 2926-11-7-61⊗	20.0	0.0	143	2.0	2.0		
-499		16.0	0.0	114	2.0	1.5		

TEST B1005. PROGENY TEST S_4's FROM POPN-926 FOR DIVERGENT SELECTION FOR REACTION TO RHIZOMANIA, SBCN, & HIGH TEMPERATURE SURVIVAL IN IMPERIAL VALLEY, BRAWLEY, CA, 2004-2005
(cont.)

Variety	Description	Stand Count No.	Bolting %	Beets/ 100' No.	Canopy Score No.	Uniformity Score	No. Eggs+Larvae 1/25/05	No. Eggs+Larvae 6/06/05
S_4 progenies from 8926 (2926-11-#-#⊗ = 1926-11-#⊗ = 9926-11⊗ = (cont.)								
4926-71 -500	Inc. 2926-11-8-71⊗	20.5	0.0	146	2.0	1.0		
-501		20.0	0.0	143	2.5	1.5		
-504		19.0	0.0	136	2.5	2.0		
-505		13.0	0.0	93	2.5	2.0		
4926-71 -506	2926-11-8-71⊗	16.0	0.0	114	2.5	1.0		
4926-72 -509	2926-11-8-72⊗	15.0	0.0	107	2.0	1.0		
-510		14.0	0.0	100	2.0	1.5		
4926-91 -517	2926-11-10-91⊗	16.5	0.0	118	2.5	1.0		
-518		15.0	0.0	107	3.5	3.0		
-519		16.5	0.0	118	2.5	1.0		
4926-92 -522	2926-11-10-92⊗	14.5	0.0	104	2.0	1.0		
-523		15.5	0.0	111	2.0	1.0		
-524		14.5	0.0	104	2.0	1.0		
-525		16.5	0.0	118	3.0	1.0		
4926-101 -528	2926-11-11-101⊗	17.5	0.0	125	4.0	2.5		
-529		20.5	0.0	146	4.5	3.0		
4926-101 -530	2926-11-11-101⊗	14.5	0.0	104	5.0	3.0		
-531		17.5	0.0	125	4.0	2.5		
4926-102 -535	2926-11-11-102⊗	19.0	0.0	136	4.5	3.0		
-536		18.5	0.0	132	5.0	3.0		
-537		17.5	0.0	125	5.0	3.0		
-538		16.0	0.0	114	5.0	3.0		
Mean		16.8	0.03	119.9	3.1	1.8		
LSD (.05)		6.2	0.75	44.5	1.1	0.9		
C.V. (%)		18.7	1385.64	18.7	18.0	24.6		
F value		1.6*	1.0NS	1.6*	6.5**	7.0**		

TEST B1005. PROGENY TEST S_4's FROM POPN-926 FOR DIVERGENT SELECTION FOR REACTION TO RHIZOMANIA, SBCN, & HIGH TEMPERATURE SURVIVAL IN IMPERIAL VALLEY, BRAWLEY, CA, 2004-2005 (cont.)

Variety	Description	Stand Count	Bolting	Beets/ 100'	Canopy Score	Uniformity	No. Eggs+Larvae	
		No.	%	No.	No.	Score	1/25/05	6/06/05

NOTES: See Tests B905 and B505.

4926-11-3-22 = CN926-11-3-22 released in 2005 and 4927-202 = CN927-202.

S_4 progenies 4926-#-# may have *Rz1* and resistance to SBCN from C51 through R22. S_2 lines were selected for selfing and increase based upon their performance at Brawley and Salinas. These S_4's were produced so that the SBCN reaction from C51 could be phenotyped and divergent, homozygous reactions identified. Each S_4 progeny is also being evaluated in field and greenhouse tests at Salinas.

Canopy scores (6/3/05) were based upon vigor, color, etc. (see B505) and plant to plant variation within each plot. Uniformity scores where 1 = homogeneous resistant; 2 = segregating; 3 = homogeneous susceptible. Canopy scores are relative and because these S_4's were being compared to lines and full-sibs (B905, for example), fewer 1's occurred due to inbreeding depression on vigor. That is to say, for these materials, 2 & 3's are good and 4 & 5's poor to very poor.

From the soil samples used to count cyst nematode, tests were run in the greenhouse to determine if there was BNYVV (rhizomania) in these trials. Based upon the ELISA results of the baited plants, Fields J and K at Brawley do not have rhizomania. Also, BOLV was not present.

CURLY TOP EVALUATION, SALINAS ENTRIES, BSDF NURSERY
KIMBERLY, ID, 2005

Planted: June 2005

264 entries x 3 reps, 2-row plots, 13 ft. long, sequential

Variety	Description		BSDF 1st Rating 8/23/05	BSDF 2nd Rating 9/13/05
Hybrids				
US H11	Resist. check, 10/14/02		3.7	4.7
HM-PM21	Resist. check, 4/05		4.0	4.7
Beta 4430R	Betaseed, 8/21/03		4.7	6.3
Acclaim	Holly Hybrids, 3/15/05		3.7	4.7
Phoenix	Holly Hybrids, 9/12/03		4.7	6.7
Beta 4001R	Betaseed, 8/25/03		4.3	6.7
HH142	Holly Hybrids, 9/12/03		4.3	5.3
Monohikari	Susc. check, 1/21/03		6.0	8.3
HM-E17	Susc. check, 4/05		4.7	7.0
Angelina	2/25/04		4.7	6.0
Roberta	Susc. check, 2/25/04		4.5	6.5
US H11	Resist. check, 10/14/02		4.0	4.5
Hybrids with C833-5CMS tester				
HM-PM21	Resist. check, 4/05		3.5	4.5
R378H5(Sp)	C833-5HO	x RZM R178, (C78/3)	4.0	4.5
P431CTH5		x RZM,CTR R278,P230,P207/8	4.0	4.5
Y475H5		x RZM-ER-% Y275	4.0	5.0
Y477H5	C833-5HO	x RZM-ER-% Y278	4.0	5.5
R421H5		x RZM-ER-% R221	4.0	5.0
K402H5		x RKNR M6-2	4.0	5.0
K403H5		x RKNR M1-3,-3a	4.5	5.5
K404H5		x RKNR M1-4	4.5	5.0
R480-6H5		x R280-6	4.0	5.0
4941-20H5		x 2941-20	4.7	5.7
4933-14H5		x 2933-14	4.7	5.3
Z431-18H5		x Z131-18	4.7	5.7
4931H5		x RZM 3931	4.3	5.0
4941H5		x RZM 3941	4.7	5.3
4943H5		x RZM 3943	4.3	5.0
Z425H5		x RZM Z325	4.7	5.7
CR411H5		x RZM CR311	4.3	5.3
N412H5		x N212-#(C),N312	4.0	5.0
N472H5		x N272-#(C),N372	4.3	5.3

Variety	Description	BSDF 1st Rating 8/23/05	BSDF 2nd Rating 9/13/05
Hybrids with C833-5CMS tester (cont.)			
N412-13H5	C833-5HO x N212-13	4.3	5.0
N412-202H5	x N212-202 4.0	5.0	
N412-203H5	x N212-203	4.3	5.0
N412-205H5	x N212-205	4.0	5.0
N472-230H5	x N272-230	4.0	5.3
N472-233H5	x N272-233	3.7	5.0
4926-11-1-3H5	x 2926-11-1-3	4.0	5.3
4926-11-3-22H5	x 2926-11-3-22	4.3	5.3
4926-11-7-61H5	x 2926-11-7-61	4.0	5.0
4926-11-10-91H5	C833-5HO x 2926-11-10-91	4.0	5.0
HM-PM21	Resist. check, 4/05	3.3	4.3
Monohikari	Susc. check, 1/21/03	5.0	7.0
R378H5	C833-5HO x RZM R178 (C78/3)	4.5	5.0
04-FC1028H5	x RZM-% FC20021028	3.5	4.5
04-FC1037H5	x RZM-% FC20021037	4.0	5.3
04-FC1038H5	C833-5HO x RZM-% FC20021038	4.7	5.7
Hybrids with C790-15CMS tester			
R378H50	C790-15CMS x R178, (C78/3)	4.0	4.7
Y392H50	x RZM Y292	4.0	5.7
Y491H50	x RZM Y391	4.0	4.7
R480-6H50	x R280-6	4.0	4.7
Y467-21H50	x RZM Y267-21	4.7	6.3
Y471-14H50	x RZM Y271-14	4.0	5.7
R443-14H50	x RZM R243-14	4.0	5.0
4941-20H50	x 2941-20	4.3	5.0
4933-14H50	x 2933-14	4.7	5.7
Z431-18H50	x Z131-18	4.0	5.0
4931H50	x RZM 3931 (C931)	4.0	5.0
4941H50	x RZM 3941 (C941)	4.0	5.0
4943H50	x RZM 4943	4.0	5.0
Z425H50	x RZM Z325 (CZ25/2)	4.0	5.0
CR411H50	x RZM CR311, (CR11)	4.0	5.0
N412H50	x N212-#(C),N312,(CN12)	4.0	5.0
N472H50	x N272-#(C),N372aa x A,(CN72)	4.0	5.0
N424H5	C833-5HO x RZM N324-#(C)	4.0	5.0
4951-210H50	C790-15CMS x 2951-210	4.0	4.0
4952-202H50	x 2952-202	4.0	4.0

CURLY TOP EVALUATION, SALINAS ENTRIES, BSDF NURSERY
KIMBERLY, ID, 2005
(cont.)

Variety	Description	BSDF 1st Rating 8/23/05	BSDF 2nd Rating 9/13/05
Hybrids with C790-15CMS tester (cont.)			
4952-205H50	C790-15CMS x 2952-205	4.0	4.0
4952-212H50	x 2952-212	4.0	4.0
4952-222H50	x 2952-222	4.0	5.0
4953-209H50	x 2953-209	4.0	4.0
4953-215H50	x 2953-215	4.0	5.0
4953-217H50	x 2953-217	4.0	4.0
4954-204H50	x 2954-204	4.0	5.0
4954-207H50	x 2954-207	5.0	6.5
4954-210H50	C790-15CMS x 2954-210	4.0	5.0
Monohikari	Susc. check, 1/21/05	5.5	7.5
4954-225H50	C790-15CMS x 2954-225	4.0	5.5
4954-231H50	x 2954-231	4.0	5.5
4924-203H50	x 2924-203	4.0	5.0
4942-202H50	x 2942-202	4.0	4.7
4942-209H50	x 2942-209	4.0	5.3
4942-211H50	x 2942-211	4.0	5.3
Z425-214H50	x Z225-214	4.0	5.0
Monohikari	Susc. check, 1/21/03	5.0	7.0
HM-PM21	Resist. check, 4/05	4.0	4.7
R378H50	C790-15CMS x R178,(C78/3)	4.0	4.7
4929-221H50	C790-15CMS x 2929-112-221	4.0	5.3
4929-227H50	x 2929-112-227	4.3	5.3
4930-229H50	x 2930-35-229	4.0	5.0
4927-202H50	x 2927-4-202	4.0	5.5
CR410-231H50	x CR210-14-2-231	3.5	5.0
CR412-211H50	x CR212-5-211	3.5	5.0
CR412-5H50	x CR212-5-#(C)	4.0	5.0
CR410-203H50	x CR210-5-203	4.0	5.0
Topcross hybrids with Y91			
Y491H5	C833-5HO x Y391	4.0	5.0
Y491H50	C790-15CMS x Y391	4.0	4.5
Y491H77	1833-5-8HO x Y391	4.0	4.5
Y491H78	1833-5-11HO x Y391	4.0	4.5
Y491H14	3869-24H5 x Y391	4.5	5.5
Y491H15	3869-27H5 x Y391	4.5	5.0
Y491H16	3869-30H5 x Y391	4.3	5.3
Y491H67	3837-6HO x Y391	4.3	5.7

CURLY TOP EVALUATION, SALINAS ENTRIES, BSDF NURSERY
KIMBERLY, ID, 2005
(cont.)

Variety	Description	BSDF 1^{st} Rating 8/23/05	BSDF 2^{nd} Rating 9/13/05
Topcross hybrids with Y91 (cont.)			
Y491H76	03-FC1014-22H5 x Y391	5.0	5.3
Y491H75	03-FC123-31H5 x Y391	4.3	5.0
Y491H73	03-FC124HO x Y391	4.0	5.0
Y491H74	03-FC1015HO x Y391	4.0	6.0
Y491H42	C842HO x Y391	4.0	5.0
R378H42	C842HO x R178(C78/3)	3.7	4.7
R378H3	C562HO x R178(C78/3)	4.0	4.7
Y491H70	C869HO x Y391	4.3	4.7
Multigerm, O.P. lines			
03-C37	resist. check, C37	3.7	4.7
04-C37	resist. check, C37	3.3	4.3
03-US75	Inc. 00-US75	3.3	4.3
03-SP22-0	Susc. check, SP22-0	4.3	5.7
EL-SP7322-0	Susc. check, SP22-0, 4/05	4.3	7.0
02-US22/3	Inc. 97-US22/3	4.0	4.3
Z210	Inc. Polish %S(C)	4.7	6.7
Y390	Inc. Y190-#(C),C2,Syn 1	4.3	5.7
Y491	RZM Y391	4.0	5.0
Y492	RZM-ER-% Y292		4.0
	5.3		
Y393	Composite FS's,C1,Syn 1	4.0	5.3
R340	RZM-ER-% R140,(C79-#s)	4.0	4.7
R424/5	RZM-% R824, (C79-2,-3; WB41,42)	4.0	4.0
R424	RZM-% R724, (C79-2; WB41)	3.7	4.0
R425	RZM-% R725, (C79-3; WB42)	4.0	4.7
R437	RZM-% R637, (C79-9; WB151)	4.0	4.7
04-C37	resist. check, C37	3.3	4.3
EL-SP7322-0	susc. check, SP22-0, 4/05	4.0	6.3
R378(Sp)	Inc. R178,(C78/3)	4.3	5.0
R380	RZM-ER-% R180,(C80/2)	4.3	5.7
Y369	RZM-ER-% Y169,(C69/2)	4.0	5.7
P431CT	RZM,CTR R278,P230,P207/8	4.3	5.3
P427	PMR-RZM P327,(CP03)	4.0	4.3
P428	PMR_RZM P328,(CP04)	4.3	4.7
P429	PMR-RZM P329,(CP05)	4.0	5.0
P430	PMR-RZM P330,(CP06)	4.0	5.0
P418-6	PMR-RZM P318-6 Iso,(CP08)	4.0	5.3
P407/8	PMR-RZM-% P207/8,(CP07)	4.0	4.3

CURLY TOP EVALUATION, SALINAS ENTRIES, BSDF NURSERY
KIMBERLY, ID, 2005
(cont.)

Variety	Description	BSDF 1st Rating 8/23/05	BSDF 2nd Rating 9/13/05
Multigerm, O.P. lines (cont.)			
K402	RKNR M6-2	4.0	4.7
K403	RKNR M1-3,-3a	4.0	4.7
K404	RKNR M1-4	4.5	6.0
R476-89	RZM-ER-% R276-89	4.0	5.0
R481-22	RZM R181-22,(C81-22)	4.0	5.0
Y475	RZM-ER-% Y275	4.0	6.0
Y477	RZM-ER-% Y277	4.0	5.0
R421	RZM-ER-% R221	4.0	5.0
Increase Full-sib progeny			
R480-6 Iso	RZM R280-6	4.0	5.5
Y467-21	RZM Y267-21	4.0	6.0
R443-14	RZM R243-14	4.0	5.0
Y471-14	RZM Y271-14	4.0	5.0
Y390-40	Inc. Y190-40	4.0	6.0
P43/CT	RZM,CTR R278,P230,P207/8	4.0	5.0
EL-SP7322-0	Susc. check, SP22-0, 4/05	5.0	6.0
04-C37	Resist. check, C37	4.5	5.0
Multigerm, S^f,Aa populations			
4931	RZM 3931aa x A,(C931)	4.5	5.0
4941	RZM 3941aa x A,(C941)	5.0	5.5
4943	RZM 3943aa x A	4.0	5.0
Z425	RZM Z325aa x A,(CZ25/2)	4.0	5.5
CR411	RZM CR311aa x A,(CR11)	4.5	6.0
4747	Inc. 0747 (A,aa)	4.5	5.5
4921	RZM-ER-% 2921 (A,aa)	3.7	5.7
N424	RZM N324-#(C)(g)(A,aa)	4.0	5.7
N412 Iso	PMR-RZM N312 (A,aa)	4.0	5.3
N412 Sp	N212-#(C),N312aa x A, (CN12)	4.0	5.3
N472 Iso	RZM-NR N372	4.0	5.3
N472 Sp	N272-#(C),N372aa x A, (CN72)	4.0	5.0
04-FC1029	RZM-% FC20021028	4.0	6.3
04-FC1037	RZM-% FC20021037	4.0	6.0
04-FC1038	RZM-% FC20021038	4.0	5.0
EL-SP7322-0	Susc. check, SP22-0, 4/05	4.0	5.5
Multigerm,S^f,Aa S_1 progeny increases			
Z325-9	RZM Z225-9(A,aa),(CZ25-9)	4.0	5.5
CR311-88	Inc. CR111-88 (A,aa)	4.0	5.0
03-FC1030-15	Inc. 01-FC1030-15 (A,aa)	4.0	5.0
03-FC1030-16	Inc. 01-FC1030-16 (A,aa)	4.0	5.0

CURLY TOP EVALUATION, SALINAS ENTRIES, BSDF NURSERY
KIMBERLY, ID, 2005
(cont.)

Variety	Description	BSDF 1st Rating 8/23/05	BSDF 2nd Rating 9/13/05
Multigerm,S^f,Aa S_1 progeny increases (cont.)			
3927-4	RZM 2927-4 (A,aa), (C927-4)	4.0	5.0
4927-202	Inc. 2927-4-202 (A,aa)	4.0	4.5
4930-229	Inc. 2930-35-229 (A,aa)	4.0	5.0
Z425-214	Inc. Z225-214 (A,aa)	4.0	5.0
4929-221	Inc. 2929-112-221 (A,aa)	5.0	5.0
4941-20 Iso	RZM 2941-20 (A,aa)	5.0	6.0
4933-14 Iso	RZM 2933-14 (A,aa)	4.3	5.3
4933-14 Sp	2933-14aa x A		4.3
	5.7		
Z431-18 Sp	Z131-18aa x A	4.7	5.7
2930-35	RZM 1930-35aa x A (C930-35)	4.0	4.7
R378 Sp	Inc. R178, (C78/3)	4.7	5.3
EL-SP7322-0	Susc. check, SP22-0, 4/05	5.0	6.0
4951-210	Inc. 2951-210 (A,aa)	4.3	6.3
4952-202	Inc. 2952-202 (A,aa)	4.3	6.0
4952-205	Inc. 2952-205 (A,aa)	4.3	5.0
4952-212	Inc. 2952-212 (A,aa)	5.0	7.0
4952-222	Inc. 2952-222 (A,aa)	5.0	6.3
4953-209	Inc. 2953-209 (A,aa)	4.7	5.7
4953-215	Inc. 2953-215 (A,aa)	4.0	5.0
4953-217	Inc. 2953-217 (A,aa)	4.0	5.0
4954-204	Inc. 2954-204 (A,aa)	4.3	5.0
4954-207	Inc. 2954-207 (A,aa)	4.0	5.0
4954-210	Inc. 2954-210 (A,aa)	3.7	5.0
4954-213	Inc. 2954-213 (A,aa)	4.3	5.3
4954-225	Inc. 2954-225 (A,aa)	4.0	5.7
4954-231	Inc. 2934-231 (A,aa)	4.0	5.7
4924-203	Inc. 2924-203 (A,aa)	5.0	6.7
4942-202	Inc. 2942-202 (A,aa)	4.3	5.7
4942-209	Inc. 2942-209 (A,aa)	4.3	6.0
4942-211	Inc. 2942-211 (A,aa)	5.0	6.3
CR410-231	Inc. CR210-14-2-231	4.3	5.7
CR412-211	Inc. CR212-5-211	4.3	6.3
CR412-5	Inc. CR212-5-#(C)	4.0	6.0
CR410-203	Inc. CR210-5-203	4.3	6.0
N412-6	Inc. N212-6	4.3	5.7
N412-10	Inc. N212-10	4.3	5.3

CURLY TOP EVALUATION, SALINAS ENTRIES, BSDF NURSERY
KIMBERLY, ID, 2005
(cont.)

Variety	Description	BSDF 1st Rating 8/23/05	BSDF 2nd Rating 9/13/05
Multigerm, S^f, Aa S_1 progeny increases (cont.)			
N412-11	Inc. N212-11	4.0	5.0
N412-13	Inc. N212-13	4.0	5.0
N412-202	Inc. N212-202	4.0	5.3
N412-203	Inc. N212-203	4.0	5.3
N412-205	Inc. N212-205	4.0	5.3
N472-230	Inc. N272-230	4.3	6.3
N472-231	Inc. N272-231	4.3	6.0
N472-233	Inc. N272-233	4.0	4.7
4926-11-1-3	Inc. 2926-11-1-3	4.3	5.3
4926-11-3-22	Inc. 2926-11-3-22	4.5	5.3
4926-11-7-61	Inc. 2926-11-7-61	4.5	5.0
4926-11-10-91	Inc. 2926-11-10-91	4.5	5.0
Monogerm populations and lines			
3842	RZM 2842(C)mmaa x A, (C842)	3.5	4.5
3869	1869(C)mmaa x A, (C869)	4.0	4.5
EL-C869	EL-C869, ELA015028, 4/05	4.0	4.5
EL-C869CMS	EL-C869CMS, ELA015027, 4/05	4.0	4.5
4842 Iso mm	RZM-% 2842 (A,aa)mm, (C842)	3.5	4.5
4843m	RZM,T-O 3843-#(C)mmaa x A	3.5	4.5
4891m	RZM,T-O 3891-#(C)mmaa x A	4.0	5.0
4846m	RZM,T-O 3846,3845-#(C)mmaa x A	3.0	4.0
4850M	Inc. 2252-2MmAa	4.0	5.0
4851M	Inc. 2252-5MmAa	4.0	6.0
4835m	RZM-% 2835(A,aa)mm	4.0	5.0
4836m	RZM-% 2836(A,aa)mm	4.0	4.5
4837m	RZM-% 2837(A,aa)mm	4.5	5.5
4892m	RZM-% 2790H7(A,aa)mm	4.0	5.5
4848	RZM-% 2848(A,aa)mm	4.0	4.0
4812M	RZM-% 6812M(A,aa)	3.5	4.0
4819M	RZM-% 6819M (A,aa)	4.0	5.0
N465m	RZM N365-N367(g)(A,aa)mm	4.0	5.0
N469m	RZM N369(g)(A,aa)mm	4.3	5.0
04-C790-15m	Inc. 00-C790-15, (C790-15)	4.3	5.7
04-C790-15HO	99-C790-68CMSxC790-15(C790-15CMS)	4.3	5.7
03-FC123-31	Inc. 01-FC123-31 (A,aa)	4.0	4.7
03-FC1014-22	Inc. 01-FC1014-22 (A,aa)	4.0	5.3
2833-5 Sp	RZM,T-O 1833-5-#(C)mmaa x A, (C833-5)	4.0	5.0

CURLY TOP EVALUATION, SALINAS ENTRIES, BSDF NURSERY
KIMBERLY, ID, 2005
(cont.)

Variety	Description	BSDF 1st Rating 8/23/05	BSDF 2nd Rating 9/13/05
Monogerm populations and lines (cont.)			
2833-5HO Sp	HO x 1833-5-#(C)mmA, (C833-5HO)	4.0	5.0
0546	Inc. 97-C546	3.3	4.0
0562	Inc. 97-C562	4.0	5.0
0762-17	Inc. 6762-17, (C762-17)	4.0	4.0
4842-226m	Inc. 2842-226(A,aa)(T-O)mm	3.5	4.0
4842-256m	Inc. 2842-256(A,aa)(T-0)mm	4.0	4.5
4842-262m	Inc. 2842-262(A,aa)(T-0)mm	4.0	4.0
4837-6-203m	Inc. 2837-6-203 (A,aa)(T-O)mm	4.0	5.0
4836-13m	RZM,T-O 3836-13-#(C)(A,aa)	4.0	4.5
4842 Iso mm	RZM-% 2842(A,aa),(C842)	3.5	4.0
4843	RZM,T-O 3843-#(C)mmaa x A	4.0	5.5
3849m	RZM 2251-2255(C)mmaa x A	4.0	5.5
2833-5NB	NB-RZM-% 0833-5(A,aa), (C833-5)	4.0	5.0
0762-17	Inc. 6762-17, (C762-17)	3.5	4.0
04-C37	Resist. check, C37	3.7	4.3
EL-SP7322-0	Susc. check, SP22-0, 4/05	5.3	7.0

NOTES: Test was fair. Part of each replication was missing. CT infection was variable.

USDA-SALINAS ENTRIES IN BETASEED DISEASE NURSERIES, SHAKOPEE, MN and FORT COLLINS, CO, 2005

		Shakopee, MN						Fort Collins		
		Cercospora Leaf Spot			Aphanomyces			Rhizoctonia		
Variety	Description	4th reading	Mean	%CR checks	Stand	Mean	Avg.%test	DI	%H	%H(0-3)
Check 1	Monohikari	7.00	4.59	122	3.23	5.08	101			
Check 2	Beta 4430R	8.97	6.40	170	2.50	5.18	103			
Y492	RZM-ER-% Y292				2.68	4.66	93			
Y475	RZM-ER-% Y275	6.66	4.26	113	2.74	4.85	97	4.9	12	20
R421	RZM-ER-% R221	7.03	4.51	120	2.21	4.36	87	4.1	20	34
04-FC1028	RZM-% FC20021028	7.00	4.28	114	1.98	5.07	101	4.9	14	25
04-FC1037	RZM-% FC20021037	5.01	3.18	85	2.13	4.45	89	4.6	7	22
04-FC1038	RZM-% FC20021038	5.68	3.50	93	2.16	5.43	108	4.3	12	28
4933-14	2933-14aa x A	4.38	3.66	98	3.30	5.70	114	6.3	2	2
4933-14H50	C790-15CMS x "	7.10	4.47	119						
CR410-203	Inc. CR210-5-203	6.69	3.85	103						
CR410-231	Inc. CR210-14-2-231	5.38	3.41	91	4.48	7.06	141			
CR412-5	Inc. CR212-5-#(C)	5.69	4.33	115	4.10	7.76	155			
CR412-211	Inc. CR212-5-211	7.10	5.17	138	4.48	7.60	152			
CR311-88	Inc. CR111-88 (CR11-88)	5.75	3.60	96	2.75	5.01	100	4.2	25	36
CR311-6	Inc. CR111-6	3.75	2.43	65						
CR311-41	Inc. CR111-41	6.08	3.67	98						
03-FC1030-15	Inc. 01-FC1030-15							3.3	37	53
03-FC1030-16	Inc. 01-FC1030-16							3.2	27	59
03-FC1014-22	Inc. 01-FC1014-22							5.1	4	14
03-SP22-0	Inc. 01-SP22-0	5.65	3.36	89	1.01	2.6	52			
4951-210	Inc. 2951-210 (A,aa)	6.35	3.94	105						
4943	RZM 3943aa x A				2.58	5.15	103			
4921	RZM-ER-% 2921				2.52	4.21	84			
Z425 (CZ25/2)	RZM Z225,Z125(C)aa x A	7.74	4.76	127	2.26	4.26	85			
4931 (C931)	RZM 3931,3931aa x A	7.13	4.84	129	2.45	4.79	96	5.1	8	21
4941 (C941)	RZM 3941,3941aa x A	7.41	4.88	130	2.67	4.15	83			
CR411 (CR11)	RZM,CR111,CR111aa x A	6.34	3.68	98	2.39	4.93	98	4.1	22	38

USDA-SALINAS ENTRIES IN BETASEED DISEASE NURSERIES, SHAKOPEE, MN and FORT COLLINS, CO, 2005
(cont.)

Variety	Description	Shakopee, MN						Fort Collins		
		Cercospora Leaf Spot			Aphanomyces			Rhizoctonia		
		4th reading	Mean	%CR checks	Stand	Mean	Avg.%test	DI	%H	%H(0-3)
N412(Sp)	N312,N212-#(C)aa x A	4.99	3.60	96	2.72	5.85	117			
N472(Sp)	N372,N272-#(C)aa x A	6.57	4.40	117	2.23	5.53	110			
K402	RKNR M6-2									
K403	RKNR M1-3,-31									
K404	RKNR M1-4									
4842 (C842)	RZM-% 2842 (A,aa)				3.07	5.61	112			
4846m	RZM,T-O 3846,3845(C)mmaa x A				2.71	5.48	109			
03-FC1030-15H50	C790-15CMS x 01-FC1030-15							4.3	8	28
03-FC1030-16H50	C790-15CMS x 01-FC1030-16							4.4	15	23
Y491H74	03-FC1015H1 x Y391							4.5	11	34
Y491H76	03-FC1014-22H5 x Y391							5.3	5	12
LSD (.05)		1.23	0.80		1.05	1.25		20.8		

NOTES: Tests managed and scored by J.Miller and M.Rekoske, Betaseed. Cercospora test at Rosemount, MN. was scored four times on the KWS scale. APH test at Shakopee, MN. was rated on a scale of 0 to 9 where 9 = dead.

Aphanomyces avg. % test: Resistant check had poor seed quality and is not present in data set.

Disease Index (DI) is based on a scale of 0 (healthy) to 7 (dead) for Rhizoctonia. Test managed by Linda Hanson.

%Healthy (%H): Percent of healthy roots (disease classes 0 and 1 combined) for Rhizoctonia.

%Healthy (0-3): Percent of diseased roots likely to be taken for processing (disease classes 0 through 3 combined) for Rhizoctonia.

TEST 2105. EVALUATION OF PLANT INTRODUCTIONS (PI's), SALINAS, CA, 2005, BLOCK 4

48 entries* x 4 reps, sequential
1-row plots, 11 ft. long

Planted: May 3, 2005
Harvested: October 31, 2005

Variety	Description	Stand Count No.	Harv Count No.	Sugar Yield Tons	Sucrose %	Bolt %	PM Score	Leaf Color Score	Bolt Tend Score	Plant Type Score	DI %	%R (0-2) %	%R (0-4) %
Checks													
US H11	susc. ck., 10/14/02	21	18	11.10	14.83	0.0	3.3	1	3	2	5.3	5.0	41.7
R039	Inc. R539, (C39R)	16	16	26.81	17.25	0.0	1.0	2	3	2	3.5	7.4	87.0
Y475	RZM-ER-% Y275	22	23	21.29	17.73	0.0	1.0	2	3	2	3.5	4.1	89.9
R421	RZM-ER-% R221	20	19	25.60	17.98	0.0	1.8	2	3	2	3.5	3.8	88.2
P428	PMR-RZM P328 (CP04)	23	19	25.45	16.90	0.0	0.8	2	3	2	4.2	1.1	66.3
04-C37	Inc. 03-C37	19	16	9.68	17.00	0.0	3.0	1	3	2	5.1	0.0	39.8
R424/5	RZM-% R824,R324/5	20	20	17.96	17.10	0.0	2.3	2	3	2	4.0	0.0	76.5
R437	RZM-% R637,R337	21	22	15.72	17.80	0.0	3.0	2	3	2	4.2	0.0	71.4
P427	PMR-RZM P327 (CP03)	21	22	18.81	17.88	0.0	0.8	2	3	2	4.7	0.0	47.8
P429	PMR-RZM P329 (CP05)	19	19	23.48	17.45	0.0	0.3	2	3	2	3.9	1.3	81.5
P430	PMR-RZM P330 (CP06)	19	20	27.31	18.17	0.0	1.0	2	3	2	3.7	0.0	85.7
EL-SP7322-0	Susc. check,SP22-0,4/05	21	18	9.17	15.75	0.0	3.3	1	3	2	5.2	0.0	34.7
Y492	RZM-ER-% Y292	21	22	27.41	17.30	0.0	2.0	2	3	2	3.6	0.0	87.8
Roberta	Susc. check, 2/25/04	16	15	15.69	15.73	0.0	1.5	1	3	2	5.0	2.3	39.3
Angelina	Resist. check, 2/25/04	19	19	27.12	18.65	0.0	5.0	2	3	2	3.5	3.6	92.1
HM-E17	HM E17, 4/05	22	19	13.13	17.67	0.0	2.5	1	3	2	5.8	0.0	33.3
***Beta vulgaris* subsp. *maritima* PI's**													
(1) Ames 4436	IDBBNR 5767	11	11	0.88		81.7	0.5	3	5	1	3.4	0.0	92.3
(2) PI504183	*Bvm* Italy	14	9	3.00	9.13	78.2	2.5	3	5	2	4.7	0.0	57.0
(3) PI504193	*Bvm* Italy	12	7	1.98		76.0	1.5	3	5	1	4.5	0.0	53.0
(4) PI504206	*Bvm* Italy	10	5	1.94		27.1	0.0	4	5	1	3.9	0.0	92.5
(5) PI504213	*Bvm* Italy	16	12	1.12		82.3	1.8	3	5	1	3.5	0.0	89.5
(31) PI504220	*Bvm* Italy	14	14	2.11	14.77	79.1	1.3	3	5	1	3.6	0.0	84.8
(6) PI504223	*Bvm* Italy	11	14	2.14		65.8	0.8	3	5	1	4.0	0.0	76.1
(7) PI504235	*Bvm* Italy	8	6	1.56		88.1	0.3	3	5	1	3.1	0.0	100.0

TEST 2105. EVALUATION OF PLANT INTRODUCTIONS (PI's), SALINAS, CA, 2005, BLOCK 4 (cont.)

Variety	Description	Stand Count No.	Harv Count No.	Sugar Yield Tons	Sucrose %	Bolt %	PM Score	Leaf Color Score	Bolt Tend Score	Plant Type Score	DI %	%R (0-2) %	%R (0-4) %
Beta vulgaris subsp. *maritima* PI's (cont.)													
(8) PI504337	*Bvm* Italy	12	11	1.23		74.3	1.0	3	5	1	4.8	0.0	55.3
(9) PI504239	*Bvm* Italy	14	11	2.74	13.25	70.7	4.0	3	5	2	3.8	0.0	91.1
(10) PI504248	*Bvm* Italy	12	10	1.29		62.7	0.5	3	5	1	3.8	0.0	78.6
(11) PI504253	*Bvm* Italy	10	9	2.14		88.4	1.0	3	4	2	4.5	0.0	70.6
(12) PI504264	*Bvm* Italy	16	11	2.19		44.6	0.8	3	3	3	5.8	0.0	39.0
(13) PI518304	IDBBNR 5798 UK	15	13	7.21	14.65	15.8	0.3	3	5	3	3.4	0.0	94.5
(14) PI518342	IDBBNR 5836 UK	19	17	1.82		74.6	0.0	3	5	1	4.3	0.0	73.6
(15) PI540631	WB885 UK	19	19	9.88	14.52	3.9	1.0	3	5	3	3.1	0.0	97.5
(16) PI540649	WB903 France	18	17	6.48	14.65	20.9	0.0	3	5	3	3.1	0.0	100.0
(17) PI540653	WB907 France	17	15	5.81	14.80	27.5	0.3	3	5	3	3.5	0.0	92.6
(18) PI540654	WB908 France	17	17	5.65	10.55	24.2	1.5	3	5	3	4.4	0.0	70.8
(19) PI540657	WB911 France	13	14	6.98	17.13	7.4	0.8	3	5	3	3.4	0.0	94.6
(20) PI540658	WB912 France	22	21	5.95	13.93	0.0	0.8	3	5	3	3.5	0.0	93.7
(21) PI540660	WB914 France	19	18	5.34	14.07	14.3	0.3	3	5	3	3.1	0.0	100.0
(22) PI540662	WB916 France	18	19	5.14	14.27	25.4	1.5	3	5	3	3.7	0.0	89.0
(23) PI540664	WB918 France	19	20	6.09	14.63	6.5	1.0	3	5	3	3.8	0.0	81.0
(24) PI540667	WB921 France	16	16	5.31	13.23	9.1	0.5	3	5	3	3.5	0.0	92.2
(25) PI540689	WB943 Belgium	19	19	5.54	13.50	5.3	2.5	3	5	3	3.9	0.0	79.5
(26) PI546404	IDBBNR 5601 Netherlands	20	20	6.65	14.20	2.2	1.0	3	5	3	3.9	0.0	81.1
(27) PI546418	IDBBNR 5612 Greece	14	11	2.18		45.2	2.0	3	5	3	4.6	0.0	69.2
(29) PI546518	IDBBNR 9865 Greece,Aegean Is.	11	0			46.1	0.0	3	5	1			
(30) PI546522	IDBBNR 9689 Greece,Aegean Is.	12	10	4.14		54.0	0.0	3	5	3	6.7	0.0	24.4
Checks													
04-FC1028	RZM-% FC20021028	20	20	21.47	17.40	0.0	1.3	2	3	2	3.4	12.6	86.0
04-FC1037	RZM-% FC20021037	22	21	22.68	17.88	0.0	1.8	2	3	2	3.5	16.5	85.1

TEST 2105. EVALUATION OF PLANT INTRODUCTIONS (PI's), SALINAS, CA, 2005, BLOCK 4
(cont.)

Variety	Description	Stand Count	Harv Count	Sugar Yield	Sucrose	Bolt	PM	Leaf Color	Bolt Tend	Plant Type	DI	%R (0-2)	%R (0-4)
		No.	No.	Tons	%	%	Score	Score	Score	Score	%	%	%
Mean		16.8	15.4	10.09	15.64	27.1	1.3	2.5	2.1	4.2	4.1	1.2	75.5
LSD (.05)		3.8	4.8	3.67	1.86	19.0	1.2	0.3	0.5	0.4	0.8	5.7	23.1
C.V. (%)		16.1	22.3	25.98	8.49	50.1	64.0	8.9	16.2	7.3	14.7	333.0	21.9
F value		9.0**	9.0**	46.82**	11.26**	22.7**	6.9**	37.7**	19.8**	42.0**	7.1**	2.6**	6.4**

*Analyses were performed on available data.
48V x 4R data available for: stand & harvest counts, %bolting, powdery mildew, leaf color, bolt tendency, plant type
47V x 4R data available for: sugar yield(tons), disease index(DI), %resistant(%R)
(data missing for V20 = PI504206 (*Bvm* Italy))
45V x 4R data available for: %soluble solids
(data missing for V20 = PI504206 (*Bvm* Italy); V27 = PI504248 (*Bvm* Italy); V45 = PI546518 (IDBBNR 9865 Greece)
34V x 4R data available for: %sucrose, sugar yield(lbs), RJAP
(data missing for V17 = Ames 4436; V19 = PI504193 (*Bvm* Italy); V20 = PI504206 (*Bvm* Italy); V21 = PI504213 (*Bvm* Italy); V23 = PI504223 (*Bvm* Italy); V24 = PI504235 (*Bvm* Italy); V25 = PI504337 (*Bvm* Italy); V27 = PI504248 (*Bvm* Italy); V29 = PI504264 (*Bvm* Italy); V31 = PI518342 (UK); V44 = PI546418 (Greece); V45 = PI546518 (Greece,Aegean Is); V46 = PI546522 (Greece, Aagean Is).

Leaf Color scored 1-5 (1 = light green; 2 = green; 3 = green-red mixture; 4 = red; 5 = chlorophyll mutant)
Bolting Tendency scored 1-4 (1 = annual; 2 = biennial; 3 = mixed annual and biennial; 4 = perennial)
Plant Type scored 1-5 (1 = fodder; 2 = leaf; 3 = sugar; 4 = table; 5 = wild)
Rhizomania score 0-9, where 9 = highly susceptible.

SUGAR BEET RESEARCH
USDA-ARS SUGARBEET RESEARCH UNIT
FORT COLLINS, COLORADO

2005 REPORT

SECTION B

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Much of this research was supported in part by funds provided through the Beet Sugar Development Foundation

USDA-ARS-NPA Sugar Beet Research Unit's Mission Statement

Utilize distinctive site environmental and disease-free characteristics and specifically developed team expertise to: develop new knowledge and adapt biotechnologies to modify host-pathogen relations that affect disease resistance, pathogenesis and epidemiology in sugar beet and other plant species pertinent to sugar beet cultivation; discover new information and techniques to identify and produce genotypes exhibiting superior disease and stress tolerance and agronomic qualities; and provide new knowledge that improves production efficiency and biochemical processing characteristics of sugar beet.

(Projects 903, 904, 420, 421, 423, 440, 441 and 443)

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UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
WASHINGTON, THE DISTRICT OF COLUMBIA

AND

BEET SUGAR DEVELOPMENT FOUNDATION
DENVER, COLORADO

NOTICE OF RELEASE OF FC723 AND FC723CMS MONOGERM SUGARBEET GERMPLASM

The USDA Agricultural Research Service (ARS), in cooperation with the Beet Sugar Development Foundation (BSDF), announces the release of FC723 and FC723CMS (PI 639917 and PI 639918, respectively) sugarbeet germplasm. These germplasm were developed in the breeding program of Drs. L. Panella and L. E. Hanson, USDA-ARS, Fort Collins, Colorado. FC723 has good resistance to root-rotting strains (AG-2-2) of *Rhizoctonia solani* Kühn and intermediate resistance to cercospora leaf spot caused by *Cercospora beticola* Sacc., but is not resistant to the *Beet curly top virus* (BCTV). FC723 is a population from which to select rhizoctonia and cercospora resistant, monogerm, O-type parents to infuse some rhizoctonia and leaf spot resistance on the female side of hybrids, and FC723CMS provides a CMS female with these characteristics. FC723 is released from seed production 951016HO and FC723CMS from 951016HO1.

FC723 is an O-type germplasm with 100% pink (*R*_) hypocotyls (89 plants counted) and is segregating for monogerm (94% *mm*). FC723 has FC708 (PI 590845), a rhizoctonia- and cercospora-resistant monogerm O-type release from the Fort Collins program as one parent. The other parent, EL44 (PI 590855), is a germplasm released from the USDA-ARS sugarbeet improvement program in East Lansing, MI, which was selected for curly top resistance and characters which enhance pollen and seed production.

FC723 is a product of five generations of mass selection for rhizoctonia resistance. It was strongly selected for monogerm and the smallest population size was 12 individuals. FC723CMS is the genetic-cytoplasmic male sterile (CMS) equivalent of FC723 backcrossed seven times. It has 100% pink (*R*_) hypocotyls (51 plants counted) and is segregating for monogerm (90% *mm*). The original cross was EL44CMS (PI 590856)/ FC708. It was backcrossed continually to the populations, from which FC723 was derived, and went through five generations of cyclic mass selection for rhizoctonia root rot resistance.

FC723 and FC723CMS exhibited good resistance to rhizoctonia root rot when tested under strong disease pressure. FC723, and FC723CMS's performance was equal to the rhizoctonia-resistant check in disease index (DI) ratings (DI of 0 = no root rot and 7 = all plants dead). FC723 had mean disease indices (DI's) of 3.8, 4.1, 2.1, and 2.6 (1999-2002, respectively), FC723CMS had mean DI's of 3.9, 4.3, 2.1, and 2.1 (1999-2002, respectively), whereas the resistant check had mean DI's of 3.8, 3.8, 2.6, and 2.9 (1999-2002, respectively).

FC723 and FC723CMS exhibited intermediate resistance to cercospora leaf spot when tested in an artificial epiphytotic. In four years of tests (1997, 1998, 1999 and 2002), they were

significantly better than the susceptible check in years of moderate disease pressure (1998 and 2002) and not significantly different from the susceptible check under more severe diseases pressure (1997 and 1999). The following DI ratings (DI of 0 = no leaf spot and 10 = all plants dead) represent the most severe rating (last of three or four ratings each season). The DIs of FC723 and FC723CMS, respectively, were 5.8, 3.5, 5.8 and 3.7; 5.4, 3.7, 5.2, and 3.3; DIs of the resistant check (FC504CMS/FC502-2//SP6322-0) were 2.9, 2.9, 2.7, and 3.7; DIs of the susceptible check (SP351069-0) were 6.5, 5.9, 6.3, and 5.0 (in 1997, 1998, 1999 and 2002, respectively). FC723 and FC723CMS showed little tolerance to the BCTV, even though the parent line, EL44, was BCTV-resistant.

Breeder seed of FC723 and FC723CMS is maintained by USDA-ARS and will be provided in quantities sufficient for reproduction upon written request to Sugarbeet Research, USDA-ARS, Crops Research Laboratory, 1701 Center Ave., Fort Collins, CO 80526-2083. Seed of this release will be deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new varieties/cultivars. We request that appropriate recognition be made of the source when this germplasm contributes to a new cultivar. U.S. plant variety protection will not be requested for FC723 and FC723CMS.

BSDF PROJECT 903 - EVALUATION OF CONTRIBUTED LINES FOR RESISTANCE TO *RHIZOCTONIA SOLANI*, A CAUSAL FUNGUS OF SUGAR BEET ROOT ROT

L. E. Hanson and L. Panella
USDA-ARS, Fort Collins, Colorado

Annually, for over thirty years, the sugar beet program in Fort Collins has included the production of an artificial epiphytotic through inoculation with *Rhizoctonia solani* to evaluate and select for resistance to Rhizoctonia root rot. We have been pleased to participate and lead this cooperative research project between the ARS, Colorado State University, and the BSDF.

In 2005 the project involved field studies conducted at the Crops Research Lab-Fort Collins Research Farm near Wellington, CO. Randomized, complete-block designs with five replicates were used to evaluate ARS breeding germplasm and Plant Introduction accessions. *Rhizoctonia*-resistant line FC703, highly resistant FC705-1, and susceptible FC901/C817 were included as internal controls.

One-row plots, planted May 25th, were 14 feet long with 22 inches between rows and 8-10 inches within-row spacing. The field was sprayed once with Betamix Progress, Upbeet, and Stinger (June 29) to control weeds. The field was thinned by hand and irrigated as necessary. Inoculation with dry, ground, barley-grain inoculum of *Rhizoctonia solani* AG2-2 isolate R-9 was performed on July 28th; immediately after inoculation, a cultivation was performed so as to throw soil into the beet crowns. Beets were harvested Sept. 19 through 22. Each root was rated for rot on a scale of 0 to 7 (dead) as previously described. ANOVAs were performed on disease indices (DIs), percent healthy roots (classes 0 and 1 combined), and percentage of roots in classes 0 thru 3. Percentages were transformed to arcsin-square roots to normalize the data for analyses. LSDs are provided for comparing entries with those of our internal checks.

The high daytime temperatures in the summer of 2005 (Figure 1), combined with a moderate inoculum load, contributed to a moderate root rot epidemic. Severe disease developed by mid-September. Mean DIs across all tests for highly resistant FC705-1, resistant FC703, and susceptible FC901/C817 controls were 2.7, 3.1, and 4.9 respectively. Mean DIs for these controls in 2004 were 2.1, 2.4 and 3.9 respectively. Percentages of healthy roots were 27.6, 25.4, and 6.4% for these controls. Percentages of roots in disease classes zero thru three were 59.1, 56.7, and 18.3% respectively. The highest and lowest DIs for the evaluated lines were 7.0 and 1.5, respectively. Table 1 shows average disease indices, percent healthy and percent in the zero thru three classes across the nursery for 2005.

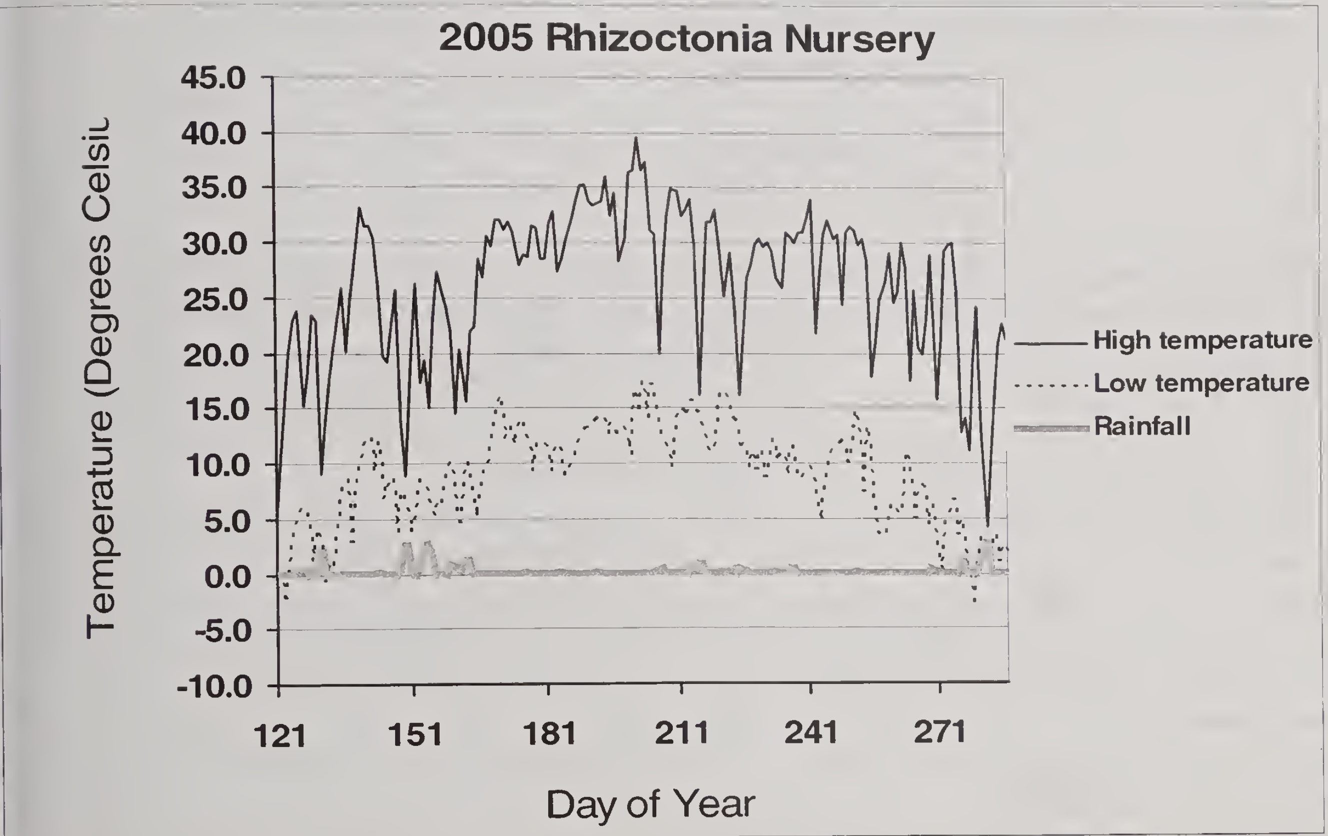


Figure 1. Summary of the weather data for 2005 Rhizoctonia root rot nursery.

Table 1. Summary data of the 2005 Rhizoctonia root rot nursery. The experiment mean, the mean of the susceptible check, the mean of the resistant check, and the mean of the highly resistant check are given for each of the experiments in the nursery. LSD is at the t=0.05 level.

	Disease Index					Percent Healthy (classes 0&1)					Percent in Classes 0 to 3				
Exp.	Mean	Sus.	Res.	HRes	LSD	Mean	Sus.	Res.	HRes	LSD	Mean	Sus.	Res.	HRes	LSD
1R	4.1	4.3	1.3	2.0	1.5	16.0	9.4	76.4	56.0	19.7	37.8	25.8	100	92.6	27.9
2R	5.5	4.3	2.7	2.8	1.4	10.8	12.4	36.4	51.4	17.1	20.8	24.2	66.2	58.0	24.5
3R	4.6	5.2	3.7	2.6	1.0	12.8	9.2	23.4	44.0	18.2	27.5	21.2	43.8	68.0	21.0
4R	4.8	4.7	3.2	3.1	1.4	29.7	18.4	45.2	62.4	15.9	58.3	47.8	74.8	98.4	18.1
5R	3.1	4.6	2.7	2.2	1.0	24.4	3.8	25.8	30.4	16.5	59.7	19.6	70.6	85.0	19.2
7R	2.7	2.5	1.6	1.6	0.8	27.6	30.6	61.8	49.4	14.4	73.9	82.2	97.8	100.0	17.5
8R	3.1	3.9	2.4	2.3	0.7	16.2	9.6	35.8	31.0	14.3	58.9	38.4	76.0	87.4	16.2
9R	4.3	4.7	3.9	3.7	0.7	16.8	9.0	19.6	51.8	17.6	60.4	20.2	76.8	93.4	18.4
10R	5.1	5.1	3.7	3.1	1.2	5.9	5.0	14.8	19.2	14.8	16.4	18.0	53.6	31.0	19.4
11R	4.5	4.5	3.6	2.8	1.1	15.0	10.4	42.8	47.2	n.s.	47.6	38.8	83.4	98.2	19.5

Percent in Classes is the transformed value (arcsin-square root)
Mean = Experiment Mean;
Sus. = Susceptible Check (FC901/C817); Res. = Resistant Check (FC703),
HRes = Highly Resistant Check (FC703); n.s. = not statistically significant

BSDF PROJECT 904 - EVALUATION OF CONTRIBUTED LINES FOR RESISTANCE TO *CERCOSPORA BETICOLA*, CAUSAL FUNGUS OF CERCOSPORA LEAF SPOT

L. E. Hanson and L. Panella
USDA-ARS, Fort Collins, Colorado

The breeding program in Fort Collins has created an annual artificial epiphytotic through inoculation with *Cercospora beticola* for over forty years. This epiphytotic has been used to evaluate and select for resistance to leaf spot caused by *C. beticola*. We have been pleased to participate in and lead this cooperative research project between the ARS, Colorado State University, and the BSDF. For 2006, the Cercospora leaf spot screening will be moving to Michigan, and will be in cooperation with Michigan State University.

In 2005, the project primarily involved field studies conducted at the Irrigation Research Center near Yuma, CO. Randomized complete-block designs, with three replications, were used to evaluate commercial and experimental entries. Internal controls included a highly susceptible synthetic (SP351069-0) and a resistant check (FC504CMS/FC502-2//SP6322-0). Two-row plots were 12 feet long, with 22-inch row spacing and an 8- to 10-inch within-row plant spacing. The trial was planted on April 26. Winds hit the plots in early May and caused some stand losses. Inoculations of plots were performed on July 13 and July 27. Evaluations were made weekly from September 7 through September 28, with the peak of the epidemic occurring around September 28. The field was sprayed with Nortron (April 26), and was sprayed seven additional times with a mix of herbicides to control weeds, but weed control was poor. The field was irrigated as necessary.

The high temperatures in the summer of 2005 and low moisture (Fig. 2) contributed to a mild leaf spot epidemic, which did not become severe enough to rate until early September. Disease severity increased through September. By the final rating (September 28), means of the resistant and susceptible internal control were 2.1 and 3.8 (scale of 0-10), respectively across the nursery. In 2004 (September 10) these means were 3.0 and 4.3, respectively. Means of contributor lines in 2005 ranged from 1.3 to 6.3. Table 2 shows the data for the nursery from the last three ratings in September.

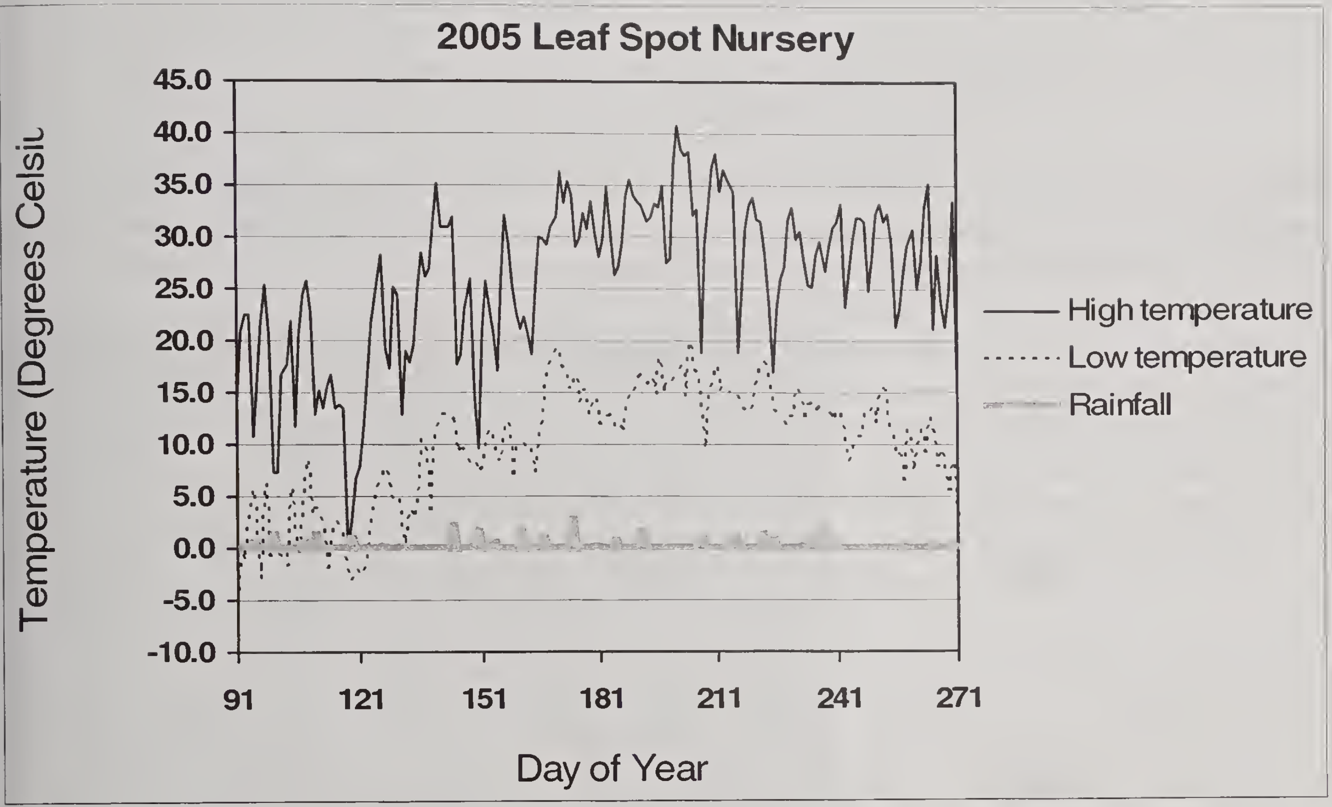


Figure 2. Summary of the weather data for the 2005 Cercospora leaf spot nursery.

Table 2. Summary data of the 2005 Cercospora leaf spot disease nursery. The experiment mean, the mean of the susceptible check, and the mean of the resistant check are given for each of the experiments in the nursery, for each evaluation date.

	September 14th Disease Index				September 21st Disease Index				September 28th Disease Index			
Exp.	Mean	Sus.[1]	Res.[2]	LSD	Mean	Sus.	Res.	LSD	Mean	Sus.	Res.	LSD
1A	2.4	2.3	1.3	1.21	3.0	3.0	1.3	1.25	3.4	3.7	2.0	1.28
3A	1.4	3.0	0.7	0.88	1.8	3.7	1.3	1.19	2.8	4.3	1.3	1.33
4A	1.9	3.0	1.0	1.25	2.5	3.0	1.8	1.47	3.2	4.0	3.3	1.07
5A	1.6	1.3	0.8	0.92	2.2	2.5	1.0	n.s.	3.0	3.2	2.2	n.s.
6A	1.3	1.7	1.2	n.s.	1.9	3.7	1.5	n.s.	2.5	4.0	1.8	1.28
Mean	**1.72**	**2.18**	**1.00**		**2.28**	**3.18**	**1.38**		**2.98**	**3.84**	**2.12**	

[1]**Cercospora Susceptible Check - SP351069-0**

[2]**Cercospora Resistant Check - FC 504CMS/FC 502-2//SP6322-0**

n.s. = not statistically significant (α=0.05)

BSDF PROJECT 420 – SCREENING BIOLOGICAL CONTROL AGENTS FOR *RHIZOCTONIA SOLANI* CONTROL ON SUGAR BEETS

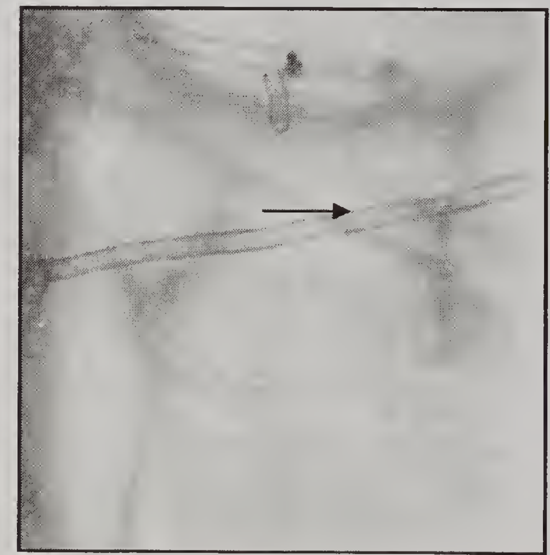
L. E. Hanson, L. Panella, A. L. Hill and G. M. Preston
USDA-ARS, Fort Collins, Colorado

Rhizoctonia root and crown rot (caused by the fungus *Rhizoctonia solani* Kühn) is the most common and most serious fungal root disease of sugar beet in the United States. The disease is endemic in beet producing areas of the United States. *Rhizoctonia solani* also causes a damping-off in sugar beet seedlings. If the infection is light, the fungus may cause crown rot or dry rot canker on maturing roots later in the season. Thus control of this fungus in the seedling stage might offer some reduction in disease later in the season, as well as improving crop stands.

Biological control can provide an alternative to chemical pesticides which are the subject of increasing regulation and restrictions due to environmental and public health concerns. Biological control is compatible with host genetic resistance and thus can be used in an IPM program. While resistance to *R. solani* is available, it does not provide complete immunity and resistance is not well expressed in seedlings, thus the addition of other control methods is desirable.

Over the course of this study, four *Pseudomonas fluorescens* and 16 isolates of *Trichoderma*, including *T. atroviride*, *T. harzianum*, *T. koningii*, *T. longibrachiatum*, and *T. virens* isolates have been obtained from various sources and tested for inhibitory activity against *R. solani* and biological control activity against *R. solani*-induced damping-off in the greenhouse. Isolates that showed greenhouse activity were screened in field tests for controlling sugar beet seedling damping-off. In addition, isolates of *Trichoderma* were screened for mycoparasitic activity against *R. solani* (Fig. 3).

Figure 3. Hyphal coiling of *Trichoderma* around *Rhizoctonia solani*. Hyphal coiling is associated with mycoparasitism in *Trichoderma*. Arrow indicates *Trichoderma* mycelium.



In *in vitro* antibiosis tests against *R. solani*, all four bacterial isolates inhibited *R. solani* growth on potato dextrose agar (PDA). In tests with *Trichoderma*, one isolate inhibited the growth of all strains of *Trichoderma* tested. An additional strain inhibited growth of isolates of three of the *Trichoderma* species, with no inhibition shown for the final two bacterial strains.

None of the bacterial strains were significantly inhibited by any of the fungi examined. When seed was soaked in a *Pseudomonas* suspension, air dried and treated with *Trichoderma* grown in wheat bran+peat moss, both *Pseudomonas* and *Trichoderma* could be isolated from the seed. Thus some of these bacteria and fungi could be used in combination on sugar beet.

In antibiosis tests against *R. solani*, six *T. virens* and two *T. koningii* isolates inhibited *R. solani* mycelial growth. Sterile culture filtrate from these isolates also inhibited *R. solani* growth (Fig. 4). Four isolates of *T. virens* and isolates of the other species showed no inhibitory activity.

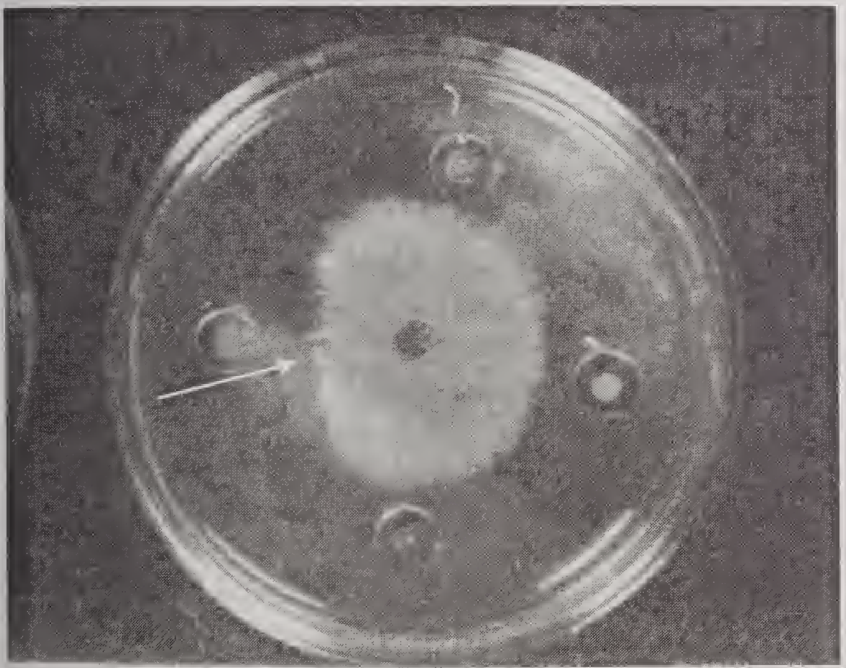


Figure 4. Inhibition of *R. solani* growth by sterile culture filtrates from *Trichoderma*. One of the four culture filtrates shows significant inhibition of *R. solani* (arrow)

In greenhouse biological control assays, no significant disease control was observed with any of the *Pseudomonas* isolates. No significant disease control was observed for the *T. atroviride*, *T. harzianum*, T. *longibrachiatum*, or *T. koningii* isolates. Seedling survival was significantly increased with wheat bran+peat moss preparations of seven *T. virens* isolates, but survival was variable. All of the *T. virens* strains colonized the root system well in the greenhouse, and there was no significant correlation between antagonistic activity or mycoparasitism and increased seedling survival in the greenhouse.

In field tests, none of the biocontrol seed treatments significantly increased seedling survival under heavy *R. solani* pressure. However, two *T. virens* isolates gave marginally better survival (P=0.05-0.10) than the fungicide control in at least two of four years of testing.

No growth promotion of sugar beet was detected for any of the *Trichoderma* or *Pseudomonas* isolates. There were no significant differences in the timing of seed germination, seedling height, seedling fresh weight or root weight between control plants and those treated with an biocontrol agent at two or three weeks after planting in the absence of *Rhizoctonia solani*.

Because of poor activity in field tests and limited personnel, this project is not being continued at this time.

BSDF PROJECT 421 – VARIABILITY IN *FUSARIUM OXYSPORUM* FROM SUGAR BEETS IN THE UNITED STATES

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Fusarium yellows causes significant reduction in root yield, sucrose percentage and juice purity in affected sugar beets. Research in our laboratory and others on variability in *Fusarium oxysporum* associated with sugar beets demonstrated that isolates that are pathogenic on sugar beet can be highly variable. A better understanding of this variability is important in the efforts to test for Fusarium yellows resistance in beets and efforts to breed for resistance.

From 2002-2004, 349 *Fusarium* isolates were obtained from sugar beet. Isolates of eight species have been identified every year of the study, included, in order of frequency, *F. oxysporum*, *F. equiseti*, *F. solani*, *F. acuminatum*, *F. avenaceum*, *F. proliferatum*, *F. subglutinans*, and *F. verticillioides*. Two other species, *F. culmorum* and *F. graminearum* have not been isolated every year, but have been isolated from several fields or a larger proportion of beets than some of the above species during some years. A small number of isolates of three additional species have been identified, but only rarely. None of these isolates were pathogenic in greenhouse tests, and so they are not discussed further.

In 2005, 298 isolates of *Fusarium* were obtained from diseased beets, and the majority identified. Two isolates showed unusual spore types, and are being sent to The Pennsylvania State University *Fusarium* research group for identification. Of the remaining isolates, fifty-four percent were *Fusarium oxysporum*. The second most common species was *F. equiseti* (22%), followed by *F. solani* (10%), *F. acuminatum* (7%) and *F. graminearum* (4%). Other species identified included *F. avenaceum*, *F. culmorum*, *F. proliferatum*, *F. subglutinans*, and *F. verticillioides*.

Over the four years of this project, a total of 690 *Fusarium* isolates have been obtained, with the majority (52%) being *Fusarium oxysporum*. Of the *F. oxysporum*, approximately 25% of the isolates tested to date are pathogenic on sugar beet. In addition, isolates of at least five other *Fusarium* species have been determined to cause yellows-type foliar symptoms on sugar beet. No isolates of *F. equiseti* have been found pathogenic on sugar beet in our greenhouse assay, but this species has been associated with postharvest mold problems in sugar beet (Bosch & Mirocha 1992).

In addition to Fusarium yellows, for which there are no external root symptoms, some of the beets in this study had root rot symptoms. Species isolated from these beets included *F. culmorum, F. graminearum, F. oxysporum,* and *F. solani*. *F. culmorum* has been reported to cause a root or crown rot under drought conditions in Europe (Hull 1960). *Fusarium solani* also has been reported to cause root rot in beets (Abada 1994, Maxon 1948). In Texas, some *F. oxysporum* isolates have been demonstrated to cause a tip rot of sugar beet (Martyn et al. 1989). These have been designated *F. oxysporum* f. sp. *radicis-betae* rather than FOB (Harveson and Rush 1998). None of the samples from which our isolates were obtained were from Texas, but results from our lab and Montana show that root rot-inducing isolates of *F. oxysporum* can occur in other areas of the United States. Three *F. oxysporum* isolates from root rot samples caused a tip rot symptom similar to that reported for isolates from Texas. Additional isolates will be tested in the future. *F. graminearum* has been reported from rotted beets at harvest (Bosch and Mirocha 1992), but the role of this species in sugar beets in the field is still being investigated.

In addition to isolates from sugar beet, *F. oxysporum* f. sp. *spinaciae* (FOS) isolates were kindly provided by Dr. L. duToit. These isolates were obtained from spinach and had been demonstrated to be pathogenic on spinach. In greenhouse tests, all spinach isolates tested were pathogenic on sugar beet with a moderate level of virulence. While these isolates are pathogenic on sugar beet, and 10 of 12 isolates from sugar beet tested were pathogenic on spinach, preliminary genetic evidence (Fig. 5) indicates that the FOS are more similar to one another than to isolates from beet.

Fusarium oxysporum

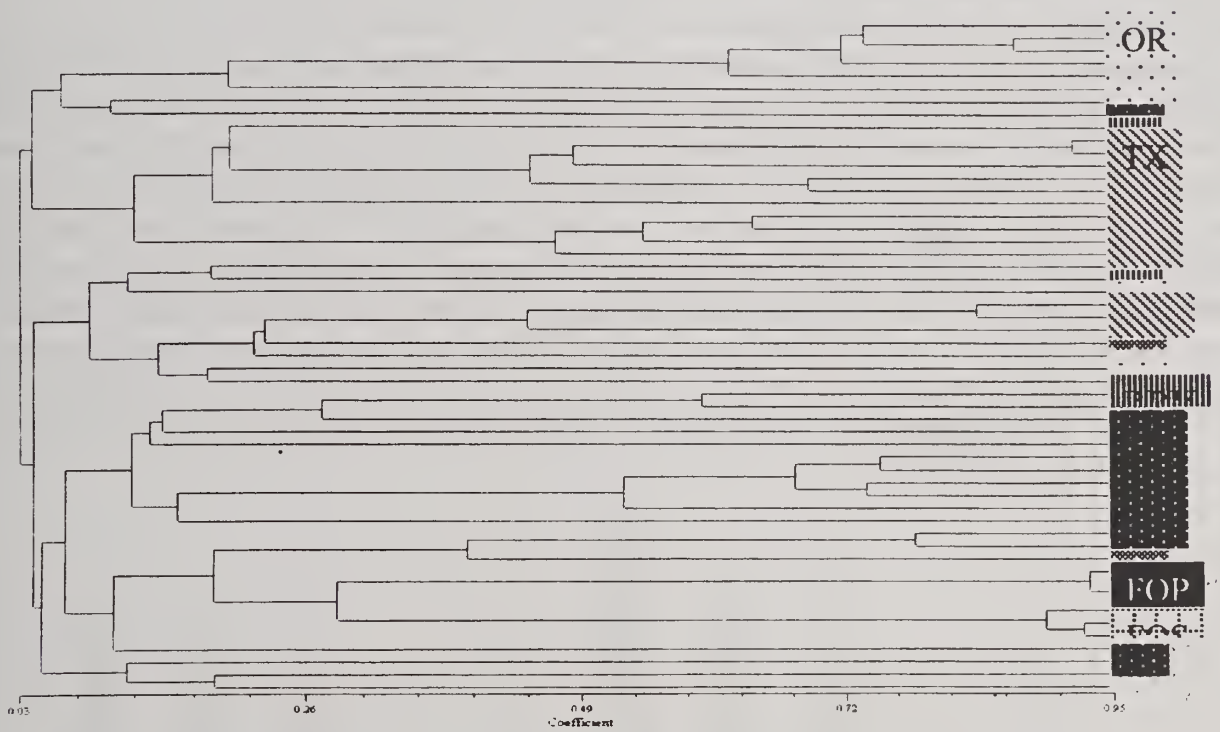

Figure 5. RAPD analysis shows a high degree of genetic variability in *Fusarium oxysporum* from sugar beet compared to isolates from spinach (FOS) or dry bean (FOP).

Isolates of *F. oxysporum* so far obtained in this study include isolates from California, Colorado, Michigan, Minnesota, Montana, Nebraska, North Dakota, Oregon, Washington, and Wyoming. Pathogenic isolates identified so far are from Colorado, Michigan, Minnesota, Montana, North Dakota, Oregon, Washington, and Wyoming. Some variability has been observed in the other species obtained in different areas. For example, the majority of the *F. graminearum* isolates are from Minnesota or North Dakota, with a few from northern Wyoming or northern Nebraska. This species was very rarely isolated in Colorado and we have not found it in any samples from Oregon or California to date.

DNA has been extracted from all pathogenic isolates obtained in 2000 and 2001, as well as isolates provided by collaborators, and used in RAPD analysis to examine genetic variability. Pathogenic isolates have been found to be a diverse group (Fig. 1). Diversity between *F. oxysporum* isolates pathogenic on beet was much higher than that reported in some other *formae speciales*, and isolates of FOS and *F. oxysporum* f.sp. *phaseoli* examined in our study showed greater clustering than the beet isolates.

A portion of the beta-tubulin gene has been isolated from several of the above *F. oxysporum* isolates and sequenced to allow for a phylogenetic comparison of isolates. A greater amount of variability has been found in this genetic sequence than was found in a set of *Cercospora beticola* isolates that were examined. The isolates sequenced to date show a high degree of similarity to previously published beta-tubulin sequences for *F. proliferatum* or isolates in the *Gibberella fujikori* group.

The ability of other species to cause disease on sugar beet is of concern since current disease control measures are aimed at controlling *F. oxysporum* f. sp. *betae*. Rotation with small grains and corn has been recommended for Fusarium yellows control, but *F. acuminatum, F. avenaceum*, *F. graminearum*, and *F. verticillioides* can be pathogens on small grains and *F. verticillioides* on corn. Thus these rotations might not aid in disease control.

The presence of several of these species of sugar beet also could be of concern for other crops grown in rotation with sugar beet, whether or not they cause disease on sugar beet. Several of the species isolated from sugar beet are generally reported to be grain pathogens. For example, *F. equiseti* was the second most commonly isolated species after *F. oxysporum*. While no isolates of this species were pathogenic on growing sugar beet, isolates of this species are important pathogens of cereal grains. Similarly, isolates of *F. avenaceum, F. acuminatum, F. culmorum*, *F. graminearum*, and *F. verticillioides* are pathogens of grains. In addition, isolates of *F. avenaceium*, *F. acuminatum*, *F. culmorum*, *F. graminearum*, and *F. solani* have been reported to cause dry rot in potatoes and *F. solani* cause a root rot of crops such as dry beans. At this time it is not known whether the isolates from sugar beet can affect these other crops, but this could be of concern for infection of crops in the rotation.

BSDF PROJECT 423 – DETERMINATION OF POTENTIAL RACES OF *FUSARIUM OXYSPORUM* F.SP. *BETAE* (FOB), THE CAUSAL AGENT OF FUSARIUM YELLOWS

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Fusarium yellows cause significant reduction in root yield, sucrose percentage and juice purity in affected sugar beets. The disease is caused by *Fusarium oxysporum* f.sp. *betae* (FOB). Research in our laboratory and others on variability in FOB demonstrated that isolates of this *forma specialis* can be highly variable. A better understanding of this variability is important in the efforts to screen for Fusarium yellows resistance in beets and efforts to breed for resistance.

In a number of *Fusarium oxysporum* formae speciales there are races that differ in their virulence on different cultivars of the host (for example at least seven pathogenic race of *F. oxysporum* f. sp. *phaseoli* are known on dry bean). We have found preliminary evidence that differences in virulence of *F. oxysporum* f. sp. *betae* may occur on different sugar beet host cultivars when we observed that, while on several sugar beet cultivars (Fig. 6), isolate FOB 216c was more virulent than FOB 13, on other sugar beet cultivars, virulence of the two isolates was similar or FOB 13 was more virulent than FOB 216c.

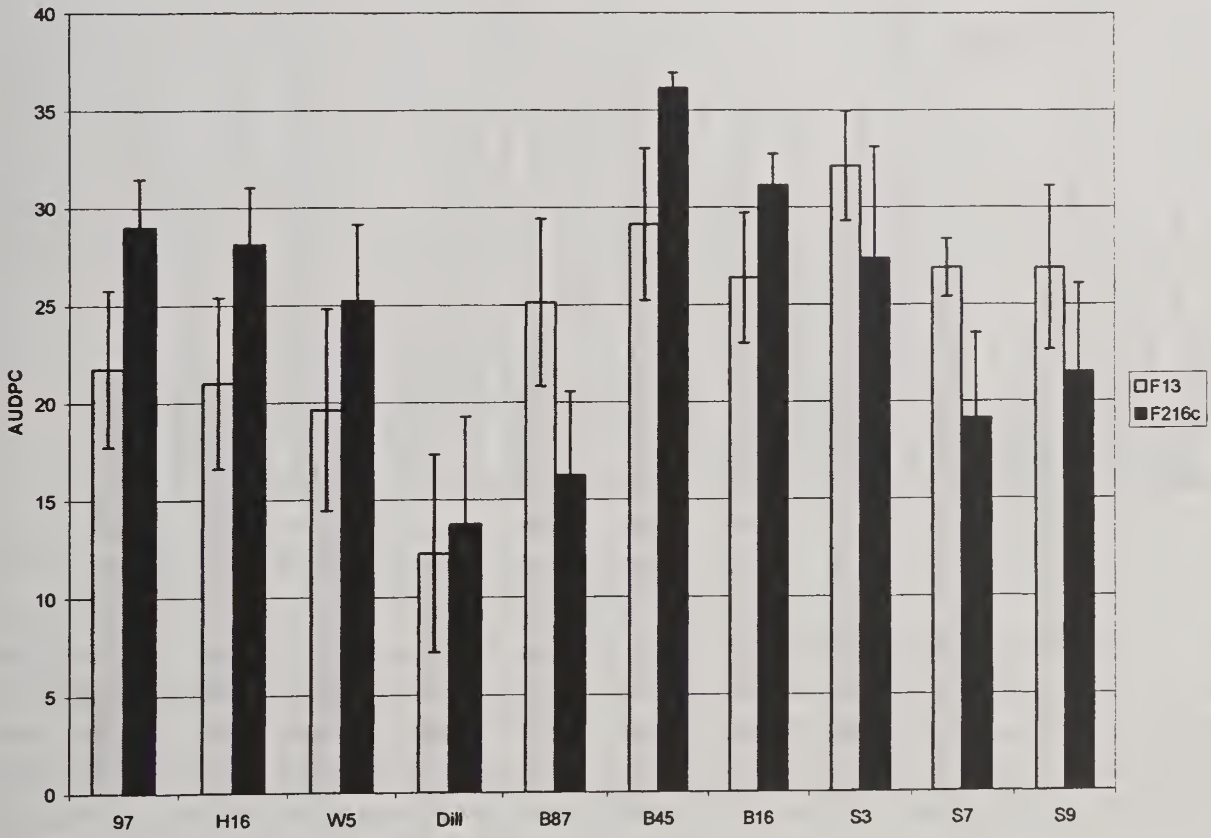

Figure 6. Disease response of 10 sugar beet cultivars to two different *Fusarium oxysporum* f. sp. *betae* isolates at moderate temperature shown as average area under the disease progress curve (AUDPC).

Nineteen sugar beet lines were generously provided by the sugar beet seed companies. The majority of these lines had shown resistance to *Fusarium* yellows in at east one test, except that two lines were provided as susceptible material. These lines, along with the Fort Collins germplasm FC716, as a standard, were tested for their reaction to FOB isolates that were from different geographic regions and showed genetic variability or variable virulence in our initial screening on germplasm FC716 (see report for BSDF project 421) or test in other laboratories. The lines were tested both in Fort Collins, CO and in Bozeman, MT. In Fort Collins, lines were rated for foliar disease severity using a 0-5 rating scale (0=no disease, 5=plant dead) for six weeks and the area under the disease progress curve was determined. In addition, at both locations, the percent of plants that were dead at 4 and 6 weeks after inoculation was determined. The isolates differed in the amount of disease they caused, with isolates Fob13, Fo24, Fo25, and Fo37 generally killing few plants during the tests. Differences were found in the response of the various sugar beet lines to the FOB isolates (Figure 7). Some lines were quite susceptible to all or most of the isolates, while other lines showed resistance to some isolates.

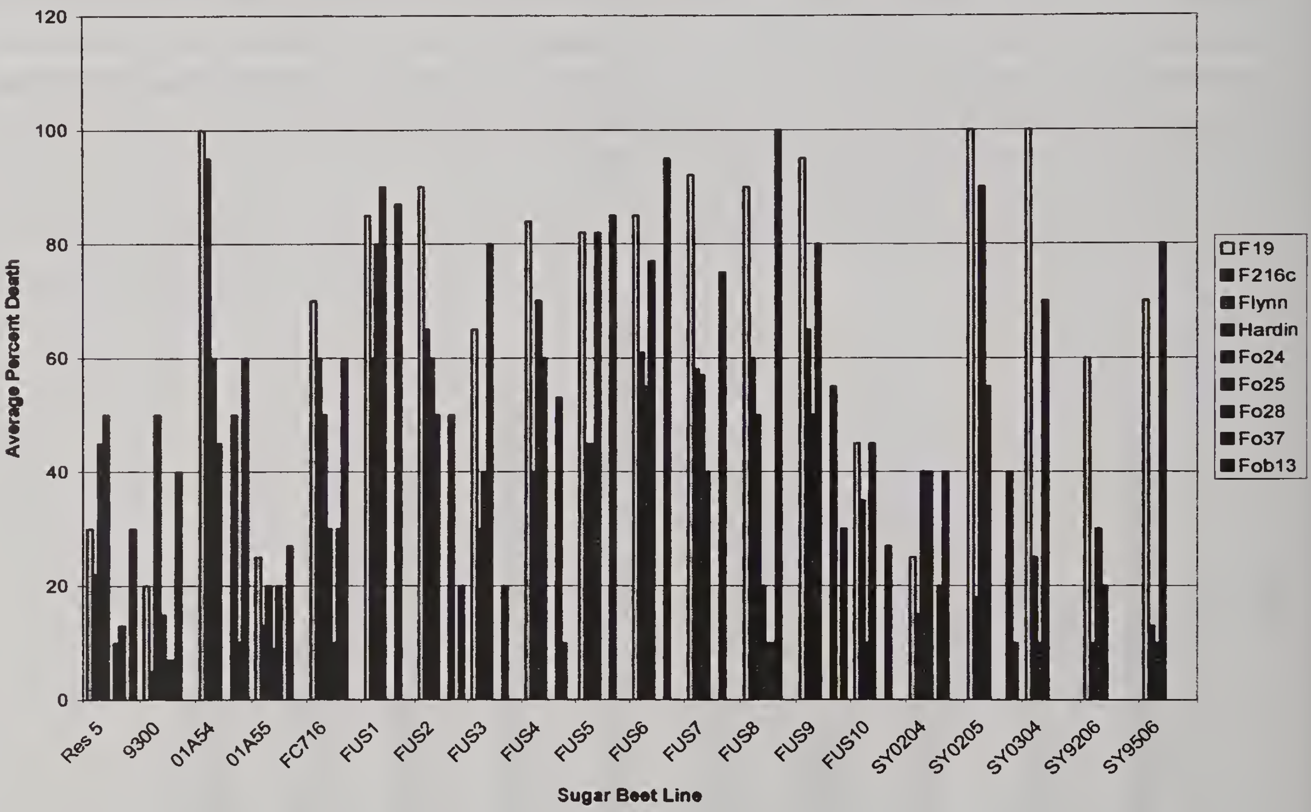

Figure 7. Average percent death of sugar beet plants of different lines treated with various isolates of *Fusarium oxysporum* f.sp. *betae.* Note isolates F19, F216c, Flynn, Hardin, and Fob13 were tested at both Fort Collins and Bozeman, and results shown are the average for the two locations. The other isolates were tested at only one location, and results shown are for those tests only. Isolates Fo24, Fo25, and Fo28 were not tested on the last three varieties due to insufficient plants.

Further work with additional isolates and genetic crosses in beet are needed to improve understanding of the interaction between FOB isolates and sugar beet. Such tests can help to determine whether the variable responses observed (above) are due to races. However, results so far indicate that screening sugar beet against a single FOB isolate or in a single region may not produce material that will show good Fusarium yellows resistance against other isolates or in different areas.

BSDF PROJECT 440 – RHIZOCTONIA ROOT ROT RESISTANCE AND DEVELOPMENT OF GENETIC RESISTANCE IN SUGAR BEET

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SUMMARY OF LITERATURE

Twenty-five years ago, Leach and Garber (1970) reviewed resistance to Rhizoctonia infection and concluded, "In general, while it has been possible to identify differences among cultivars or selections in susceptibility to Rhizoctonia infection, it is extremely rare that a high degree of resistance has been found or produced by selection or breeding within a susceptible host species." However, one of the most effective and environmentally safe ways to manage plant disease is with resistant germplasm (Sherf and MacNab, 1986). Soilborne pathogens like Rhizoctonia are often difficult to control chemically. Fumigation is expensive, providing only a temporary solution. The use of Quadris™[1] provides the first real chemical control for this disease. However, we are finding that timing of application is crucial. Additionally, spot spraying can be time consuming, and spraying a whole field because of a few patches of disease also can be expensive. The use of resistant germplasm, coupled with crop rotation and other cultural practices, can provide excellent management of diseases caused by *Rhizoctonia solani*.

In sugar beet (*Beta vulgaris* L.), Rhizoctonia root- or crown-rot is caused by *Rhizoctonia solani* (AG-2-2). Seedling damping-off in sugar beet primarily is caused by *R. solani* AG-4 and AG-2-2. Root-rot is endemic in sugar beet growing areas across the United States. John Gaskill began breeding for resistance in the late 1950s and released his first resistant germplasm in 1966 (Gaskill, 1968). Current Rhizoctonia resistant germplasm has a level of resistance in which there is no yield loss under disease pressure in the field (Ruppel and Hecker, 1994). It was realized early that natural field epiphytotics did not produce the necessary consistent, uniform disease pressure for recurrent mass selection (Pierson and Gaskill, 1961). Artificially induced epiphytotics (Ruppel et al., 1979; Schneider et al., 1982) were developed to provide uniform, heavy disease pressure to be able to perform mass selection or recurrent field selection (Hecker and Ruppel, 1977).

The resistance to *R. solani* in sugar beet developed by John Gaskill is polygenic, involving at least two loci, two or three alleles, and modifying genes in some populations (Hecker and Ruppel, 1975). Broad-sense heritability has been estimated at about 0.65, and there are non-additive components of the variance (Hecker and Ruppel, 1975). In a study by Hecker and Ruppel (1976) dominance effects were present in diploid, triploid, and tetraploid resistant hybrids. Relatively high heritability has aided in the development of increasing host plant resistance to Rhizoctonia root- and crown-rot, and we have released over 15 germplasm lines in the last 10 years. Rhizoctonia Resistance has been released in O-type maintainer, CMS female, and multigerm-pollinator germplasm and remains a very important means of reducing crop damage by this disease (Herr, 1996). Genetic resistance to Rhizoctonia root rot has been an ongoing development from this project at Fort Collins.

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[1]Mention of a trademark or manufacturer by the USDA does not imply its approval to the exclusion of other products or manufacturers.

Several resistant germplasms have been released in the last five year to use as parents of hybrid cultivars or to provide source populations from which Rhizoctonia resistant parents were selected or which were crossed to provide resistant parents (Panella and Ruppel, 1996; Panella and Ruppel, 1997; Panella, 1999; Panella, 2001).

Epidemiological and control studies have been reported regularly from this project (Ruppel et al., 1988). Pathogen survival in varied crop debris and soil and the interaction of pesticides with Rhizoctonia have been reported on the literature (Ruppel, 1985; Ruppel 1991; Ruppel and Hecker, 1982; Ruppel et al., 1982). In a 3-year study, positive significant or highly significant correlations between disease severity indices and percent decreases in yield and purity parameters indicated that there were no hidden losses to Rhizoctonia root rot in our resistant germplasms (Ruppel and Hecker, 1994).

Recently, researchers attempting to determine the anastomosis group (AG) of *Rhizoctonia solani* isolates have used several new biotechnological techniques (including RFLP, RAPD, and isozyme analyses), with some notable successes in distinguishing among, and even within some, of these groups. Recently there was a report of a definitive assay to distinguish those isolates in AG-2-2 or AG-4 that cause sugar beet root rot and damping-off, respectively, from nonpathogenic isolates obtained from soil (Lubeck and Poulsen, 2001).

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JUSTIFICATIONS FOR THIS RESEARCH:

Rhizoctonia root rot continues to be a problem in most sugar beet-growing areas in the United States, and is a growing problem worldwide. The practice of short rotations and the expansion of growing areas into infested areas compound the problem. The result is a reduction in net returns to growers as well as processing losses due to reduced sucrose and purity of rotted or partially rotted beets. Genetic resistance, coupled with judicious cultural measures, is a more economical and practical method of reducing losses caused by this fungus than is a strictly chemical control regime. There is also a strong need of combining Rhizoctonia root rot resistance with Rhizomania resistance.

This has been an ongoing and productive project, and has been the only research project with the goal of discovering, developing, and releasing Rhizoctonia-resistant germplasm to industry breeders, our major external customers. Although several relatively resistant germplasms have been developed, we need to continue to combine this resistance with resistance to other diseases, and to develop a faster means of introgressing this resistance into more commercially acceptable materials.

OBJECTIVES:

1. Develop Rhizoctonia-resistant populations from different genetic sources of resistance.
2. Plant mother roots and selections for seed production and ultimate release to breeders for use as populations from which to develop Rhizoctonia- and rhizomania-resistant parents in hybrid cultivars.
3. Combine resistance to *Rhizoctonia* with that of other important pathogens (esp. Rhizomania) in germplasm with good agronomic performance.
4. A longer range goal (in collaboration with Mitch McGrath, USDA-ARS East Lansing) is the development of molecular markers linked to the genes in sugar beet controlling resistance to *R. solani*.

MATERIALS AND METHODS:

Field isolation plots and greenhouse isolation chambers in Fort Collins will be used for seed production from mother roots and selections of advanced germplasms having been field selected for resistance to Rhizoctonia root rot. The Fort Collins environment has proven extremely valuable in these efforts. The arid climate, low organic matter content of the soils, and hot, dry winds are not conducive to the development of soilborne or foliar diseases. Therefore, when artificial epiphytotics, developed by Gaskill and Ruppel, are created to test sugarbeet for resistance to Rhizoctonia root rot there is little confounding of the results by the presence of other diseases.

Selected resistant populations resulting from crosses with material containing the single *Rz* gene source of resistance to Rhizomania will be sent to Salinas for field selection for Rhizomania resistance. Alternating cycles of selection in Salinas and Fort Collins (and Kimberley, ID for curly top resistance) will be used to increase disease resistance. Seed increases will be made and the germplasms will be released as adequate seed becomes available.

Molecular genetic studies will concentrate on looking at the response of the sugar beet to attack by *Rhizoctonia solani*. A longer range goal (in collaboration with Mitch McGrath, USDA-ARS East Lansing) is the development of molecular markers linked to the genes controlling resistance to *R. solani*. Populations are being developed at East Lansing for this purpose and molecular markers (SSRs & AFLPs) at both Fort Collins and East Lansing.

2005 Field Research on Rhizoctonia Root Rot of Sugar Beet

Annually, for over thirty years, the sugar beet breeding program in Fort Collins has included the production of an artificial epiphytotic through inoculation with *Rhizoctonia solani* to evaluate and select for resistance to root rot caused by this pathogen. In 2005 the project involved field studies conducted at the Crops Research Lab-Fort Collins Research Farm near Wellington, CO. Randomized, complete-block designs with five replicates were used to evaluate ARS breeding germplasm and Plant Introduction accessions. *Rhizoctonia*-resistant line FC703, highly resistant FC705-1 and susceptible FC901/C817 were included as internal controls. One-row plots (56 cm row spacing) were 4 m long and were planted at the Crops Research Lab-Fort Collins Research Farm, CO, on May 25. Inoculation with dry, ground, barley-grain inoculum of *Rhizoctonia solani* isolate R-9 (AG-2-2) was performed on July 28 at a rate of 25 g/m row with inoculum applied to the crown of the plant. Immediately after inoculation, plots were cultivated to throw soil into the beet crowns. The plant population was thinned to 20-25 cm spacing by hand and irrigated as necessary. Beets were harvested September 19, and each root was rated for rot on a scale of 0 (no damage) to 7 (dead plants). The average disease severity was determined to create a disease index for each PI. Analyses of variance (PROC ANOVA - SAS) were performed on disease indices (DI), percent healthy roots (classes 0 and 1 combined) and percentage of roots in classes 0

through 3 (harvestable roots). Percentage of roots in classes 0-1 and 0-3 were transformed using arcsine-square root to normalize the data for analyses (AP 0-1 and AP 0-3, respectively).

Rhizoctonia root rot reached moderate severity levels in early September. Differences in the DI among entries were highly significant ($P < 0.001$). The average DI across all tests in the 2005 nursery for highly resistant FC705-1, resistant FC703, and highly susceptible FC901/C817 controls were 2.7, 3.1, and 4.9, respectively. Percentages of healthy roots (those in disease classes 0-1) were 27.6, 25.4, and 6.4% for these controls, respectively. The percentages of harvestable roots (those in disease classes 0-3) were 59.1, 56.7, and 18.3% for these controls, respectively. The highest and lowest DI for all of the lines evaluated in the nursery, including materials not in the PI tests, were 7.0 and 1.5, respectively.

Table 3. Allotment of Fort Collins "FC" numbers (3-digit numbers)

"FC" numbers are "convenience" numbers for "seed releases" or purposes where a permanent line designation is needed — i.e. a number that does not change from generation to generation where little or no selection pressure is applied. Initially, an "FC" no. was written thus "FC 501" [now FC727], "FC 502 CMS" [now FC715CMS], etc. Sublines (from selfing) were designated thus, "FC 502/2" [now FC709-2], "FC502/3" [now FC502-3], etc. The same applies when the line is substantially changed by selection without selfing.

100's	Early releases
200's	Rhizoctonia, rhizomania resistant, combined with other resistances
300's	Leaf Spot Resistant (LSR), combined with rhizomania resistance
400's	Parental lines and special genetic stocks
Below 500	Originally LeRoy Powers -
500's	Leaf Spot Resistant (LSR), Type-O lines & male steriles [CMS]
600's	LSR-Curly Top Resistant (CTR), type-O lines & male steriles [CMS]
700's	Rhizoctonia Resistant
800's	LSR-CTR-Rhizoctonia resistant
900's	Pollinators, LSR-CTR type

Rhizoctonia-Resistant Populations under Development

Rhizoctonia root rot continues to be a problem in most sugar beet-growing areas in the United States, and is a growing problem worldwide. The practice of short rotations and the expansion of growing areas into infested areas compound the problem. The result is a reduction in net returns to growers as well as processing losses due to reduced sucrose and purity of rotted or partially rotted beets. Genetic resistance, coupled with judicious cultural measures, is a more economical and practical method of reducing losses caused by this fungus than is a strictly chemical control regime. There is also a strong need of combining Rhizoctonia root rot resistance with Rhizomania resistance.

This has been an ongoing and productive project, and has been the only research project with the goal of discovering, developing, and releasing Rhizoctonia-resistant germplasm to industry

breeders, our major external customers. Although several relatively resistant germplasms have been developed, we need to continue to combine this resistance with resistance to other diseases, uncover new sources of resistance, and work to more quickly introgress this resistance into germplasm with higher sucrose yield potential.

Current Research 2005 – Germplasm under Development

Current Rhizoctonia-resistant germplasm under development consists of populations being jointly developed with Dr. Robert Lewellen in Salinas. These populations are being improved to combine Rhizoctonia and Rhizomania resistant in a genetic background with good sucrose yield potential. Additionally, a population providing root maggot resistance along with Rhizoctonia and Cercospora resistance is under development with Larry Campbell in Fargo. Finally, potential new sources of Rhizoctonia have been identified, are being retested and will be crossed to sugar beet with high sucrose potential and Rhizomania resistance.

With the release of FC723 and FC723CMS last fall, the germplasm remaining from the program of Dr. Richard Hecker has been evaluated, recombined, improved and released or shelved.

Table 4: Salinas
Seed Sent to R. T. Lewellen

Release	Seed No.	Germplasm, release no. or description	Date Sent	Salinas ID
FC201	19951014	(941009H2 + 941009H3) - 951014; ((2890aa x FC708) + (2859aa x FC708))F1 - blk F2	04/01/99	FC1014
FC301	19981010H	([2859aa x (FC607 & FC604)] + [2890aa x (FC607 & FC604)]) - blkF1 -blkF2 - S1 - blkLSR; 981010 = Mix of 20 g 971011 with 11 g of 971013MS and 11 g of 971013PF.	05/01/98	FC123
FC301	19981011H	([2859aa x (FC607 & FC604)] + [2890aa x (FC607 & FC604)]) - blkF1 -blkF2- S1 - RMCTR(1s, 6s, 26s, 88s, 94s)aa - blk PF; (941007H2 + 941007H3) - 951013 - 961007 - 971012ms	05/01/98	FC123
FC301	19981012	CTR/LSRmmpop -- ([2859aa x (FC607 & FC604)] + [2890aa x (FC607 & FC604)]) - blkF2 - S1 - blk rem CTR	05/01/98	FC123
FC301	19991012	971012 -- ([2859aa x (FC607 & FC604)] + [2890aa x (FC607 & FC604)]) - blkF2 - S1 - blkCTR(1s, 6s, 26s, 88s, 94s) - selected by G Koch via leaf disc	07/25/00	FC123
√ 05-1030-15	19991030MS	((2915aa x FC709-2) + (FC709-2rr x 2915A_))blkF1-blkF2-RMF3- Hs; (941011H2 +941012H2) - 961004 - 971015Aa - 981006-x [Polycross increase of 981006-10, -15, -17, -21, -60, -70] - male sterile harvested	07/25/00	FC1030
√05-130-16	19991030PF	((2915aa x FC709-2) + (FC709-2rr x 2915A_))blkF1-blkF2-RMF3- Hs; (941011H2 +941012H2) - 961004 - 971015Aa - 981006-x [Polycross increase of 981006-10, -15, -17, -21, -60, -70] - pollen fertile harvested	07/25/00	FC1030

Release	Seed No.	Germplasm, release no. or description	Date Sent	Salinas ID
	19991031MS	((2915aa x FC709-2) + (FC709-2rr x 2915A_))blkF1-blkF2-RMF3- Hs; (941011H2 +941012H2) - 961004 - 971015Aa - 981006-x [Polycross increase of 981006-6, -12, -19, -27, -34, -37, -38, -41, -43, -48, -65, -68] - male sterile harvested	07/25/00	FC1030
	19991031PF	((2915aa x FC709-2) + (FC709-2rr x 2915A_))blkF1-blkF2-RMF3- Hs; (941011H2 +941012H2) - 961004 - 971015Aa - 981006-x [Polycross increase of 981006-6, -12, -19, -27, -34, -37, -38, -41, -43, -48, -65, -68] - pollen fertile harvested	07/25/00	FC1030
	19991032MS	((2915aa x FC709-2) + (FC709-2rr x 2915A_))blkF1-blkF2-RMF3- Hs; (941011H2 +941012H2) - 961004 - 971015Aa - 981006-x [Polycross increase of 981006-18, -54, -56, -59, -71, -110] - male sterile harvested	07/25/00	FC1030
	19991032PF	((2915aa x FC709-2) + (FC709-2rr x 2915A_))blkF1-blkF2-RMF3- Hs; (941011H2 +941012H2) - 961004 - 971015Aa - 981006-x [Polycross increase of 981006-18, -54, -56, -59, -71, -110] - pollen fertile harvested	07/25/00	FC1030
	20001004	(961002aa x 961001)F2blk; {((4918(sp)aa x (FC902 x 278R-)) + (4918(sp)aa x (278R- x FC902))) - blkF1 -aa} X {(FC607 x (MonoHy-T6, -A7, -A4, & SR87)) - blk(Ss?)F2} - F2blk	07/25/00	FC1030
	20021028	(2000A011 x 19921024)rr blk F2; 9933rr x FC709-2; RhzcR, LSR, RtAphidR, Sf, A-, Rz-, fertile cytoplasm	04/08/03	04-FC1028
	20021038	[2001A032=CR910 blk]x[(20001014H2+20001014H4+20001015H2+20001015H4+20001015H5+20001015H6+20001015H7) blk increase]F2	04/08/03	04FC1038
	20021037	[2000 Seed Production Sp5 - (Rzm CR910, 911, 912 aa x A-) blk] x [(20001014H2+20001014H4+20001015H2 +20001015H4+20001015H5+20001015H6 +20001015H7) blk increase]F2	04/08/03	04-FC1037
	20031018	(2000A010[9931rr] x 9210124[FC709-2R-])F1-blkF2-blkF3; 74 females harvested, 24 males in F1	04/14/04	FC????
	20031019	(981007-x & 981006-x)blk; ((941011H2 +941012H2) - 961004 - 981007-x Rhzc sel & (941011H2 +941012H2) - 961004 - 971015Aa - 981006-x Rhzc sel)blk-blk-blk	04/14/04	FC????
	20031022	[2000A010aa [9931] x 20001009 [sel(FC907 x FC709-2)F3]blk increase-blk	04/14/04	FC????
	20021023	reselection of FC123 for LSR	07/27/04	

Some of the Populations under Development are:

1. Rhizoctonia root rot resistance multigerm base population developed by a cross between FC709-2 and a Salinas germplasms, 2915, which has been tested in Salinas & Fort Collins as FC1030). – includes populations 03-FC1030-15 and 03-FC1030-16 being reselected in Fort Collins for Rhizoctonia resistance.
   a) 2915 (sp) RZM 1915-#m 1913-# aa x A (Salinas); Seed harvested from aa (ms) plants open-pollinated by A- (fertile) plants. This population will segregate for A-:aa, Rz-:rzrz, $s^s s^s$:s^f-, (>½ s^f), R-:rr, It will be multigerm, have moderate to good tolerance to virus yellows, curly top, bolting, Erwinia; variable for reaction to powdery mildew, production traits. Individual plants will be either Aa or aa. Background of population is mostly from OP, MM lines such as C46, C37.
2. 20021028; FC709-2 (Fort Collins release) x 9933 (Salinas germplasm) [(2000A011 x 19921024)rr blk F_2]; Should segregate for rhizoctonia and cercospora leafspot resistance (FC709-2), multigermity, root aphid resistance (FC709-2 and 9933), tolerance to curly top, Virus Yellows, powdery mildew, Erwinia, rhizomania (9933) S^f-, A-, in a fertile cytoplasm – tested in Salinas as 04-FC1028.
3. Sib-lines of FC201 – 01-FC1014-22 (A,aa); 01-FC1014A; 01-FC1014H5 – C833-5 CMS x 01-FC1014A; 03-FC1015 – Rzm (C833-5 mmaa x FC1014) mmaa x A; 03-FC1015HO, CMS equivalent of the previous – (C833-5 CMS x 01-FC1014A) x Rzm (C833-5 mmaa x FC1014) mmaa x A.
4. 20021022 – [2000A010aa [9931] x 20001009 [sel(FC907 x FC709-2)F3]blk increase-blk – was sent to Salinas and reselected in Fort Collins.
   a) 9931 = Advanced Base breeding population at Salinas with resistance/tolerance to Rz, CT, VY, Pm, Erwinia, bolting – segregates for Aa:aa, Sf, Multigerm.

PROGRESS IN 2005:

1. Sib-lines from the population (20001004, 19991030, 10001031, and 19991032), 051030-15 and 05-1030-16 will be released as FC220 and FC221. They have a high frequency of the *Rz1* allele conferring resistance to rhizomania caused by *Beet necrotic yellow vein virus*, and excellent resistance to root-rotting strains (AG-2-2) of *Rhizoctonia solani* Kühn.
2. Seed received from R.T. Lewellen for testing and evaluation includes Accession seed numbers from 2005A005 to 2005A027 (Table below).
3. A number of accessions from the NPGS *Beta* collection that had shown Rhizoctonia-resistance in the Sugarbeet CGC screening program have been identified. Those PIs with seed available were re-screened in 2003. Special attention will be paid to those accessions screened in 1987 and 1992 because the tests in those years appear to have been unreliable. These and other PIs are being screened (Table below). Crosses will be made between any that appear to have resistance using a female parent with high sucrose yield potential and with Rhizomania resistance. The goal is to develop Rhizoctonia-resistant populations from potentially different sources of resistance, from which breeders will be able to select resistant hybrid parents or germplasm to cross into programs developing Rhizoctonia-resistant hybrid parents (See table below).

Table 5:

Germplasm Received from RT Lewellen at Salinas for evaluation, crossing, and selection.			
Number	PARENTDESC	Designation	Pedigree
2005A005	bulk increase of (FC709-2 x 9933) & (Best LSR FC x EL x CR11) & (Best LSR FC x EL x CR10)	05-FC1036	05-FC1036 = [(rzm 04-FC1028, RZM 04-FC1037, RZM 04-FC1038)aa x A]; 04-FC1028 = rzm-%S FC20021028 (FC709-2 x 9933); 04-FC1037 = rzm-%S FC20021037 (Best LSR FC x EL x CR11); 04-FC1037 = rzm-%S FC200210378(Best LSR FC x EL x CR10)
2005A006	C833-5cms x FC1036	05-FC1036H5	05-FC1036H5 = C833-5cms x FC1036A;FC1036=2005A005; C833-5 cms = mm, Rz1Rz1, ♀ tester, cms
2005A007	C790-15cms x FC1036	05-FC1036H50	05-FC1036H50 = C790-15cms x FC1036A; FC1036=2005A005; C790-15 cms = mm, Rz1Rz1, ♀ tester, cms
2005A008	{[(4918aa x (FC902, FC607, Commercial)]F2; (2915 x FC709-2) recriprocal} blk	05-1030-15(Sp)	= 03-FC1030-15aa xA; 03-FC1030-15 = Inc. 01-FC1030-15(A,aa); 01-FC1030-15 = FC1030(c)aa x A (½ sib); FC(C1)=rzm MR of 20001004(48), 19991030MS(27), 19991030PF(23), 19991031MS(10), 19991031PF(5), 19991032MS(24), 199910302PF(24); 40 stecks/each
2005A009	{[(4918aa x (FC902, FC607, Commercial)]F2& (2915 x FC709-2) recriprocal}blk x C833-5cms	05-FC1030-15H5	05-FC1030-15H5 = C833-5cms x FC1030-15A;FC1030-15=2005A008; C833-5 cms = mm, Rz1Rz1, ♀ tester, cms
2005A011	1/2 sib 2005A008 {[(4918aa x (FC902, FC607, Commerc)]F2; (2915 x FC709-2) recriprocal} blk	05-FC1030-16(Sp)	= 03-FC1030-16aa x A; 03-FC1030-16 = Inc. 01-FC1030-16(a,aa); 01-FC1030-16 = FC1030(c)aa x A (½ sib); see 2005A008; ½ sib = one aa plant pollinated by A_ (fertile) plants from composite of MR & stecklings. Source of single♀ seed bearing plant not known.
2005A012	{[(4918aa x (FC902, FC607, Commercial)]F2; (2915 x FC709-2) recriprocal}}blk x C833-5cms	05-FC1030-16H5	05-FC1030-16H5 = C833-5cms x FC1030-16A;FC1030-16=2005A011; C833-5 cms = mm, Rz1Rz1, ♀ tester, cms
2005A013	{[(4918aa x (FC902, FC607, Commercial)]F2& (2915 x FC709-2) recriprocal}blk x C790-15cms	05-FC1030-16H50	05-FC1030-16H50 = C790-15cms x FC1030-16A; FC1030-16=2005A011; C790-15 cms = mm, Rz1Rz1, ♀ tester, cms
2005A014	{[(4918aa x (FC902, FC607, Commercial)]F2; (2915 x FC709-2) recriprocal} blk	05-FC1030-15(iso)	05-FC1030-15(iso) = rzm 03-FC1030-15(A,aa) ; bulk increase in greenhouse isolation chamber (not distributed)
2005A015	1/2 sib 2005A008 {[(4918aa x (FC902, FC607, Commerc)]F2; (2915 x FC709-2) recriprocal} blk	05-FC1030-16(iso)	05-FC1030-16(iso) = rzm 03-FC1030-16(A,aa) ; bulk increase in greenhouse isolation chamber (not distributed)
2005A016	half sibs of FC123mm (FC301); multigerm	05-FC1023M(sp)	05-FC1023M(Sp) = Inc. 20021023Maa x A; Multigerm, aa plants, x all A_ plants; Only a fair seed plot. Risk of out crossing to other mm populations.

Germplasm Received from RT Lewellen at Salinas for evaluation, crossing, and selection.			
Number	**PARENTDESC**	**Designation**	**Pedigree**
2005A017	half sibs of FC123mm (FC301); monogerm	05-FC1023m(Sp)	05-FC1023m(Sp) =Inc. 20021023mmaa x A; monogerm, aa plants, x all A_ plants, mostly M_; Only a fair seed plot. Risk of out crossing to other mm populations.
2005A018	C833-5cms x FC20021023 (mm of LSRmm pop & CTR/LSRmm pop & CTR/LSRmm pop)	05-FC1023H5	05-FC1023H5 = C833-5cms x 20021023mmA; C833-5 cms = mm, Rz1Rz1, ♀ tester; 20021023 = half sibs of (mm of LSRmm pop & CTR/LSRmm pop & CTR/LSRmm pop); Only a fair seed plot. Risk of out crossing to other mm populations.
2005A019	C790-15cms x FC20021023 (mm of LSRmm pop & CTR/LSRmm pop & CTR/LSRmm pop)	05-FC1023H50	05-FC1023H50 = C790-15cms x 20021023mmA; C790-15cms = mm, Rz1Rz1, ♀ tester, cms; Only a fair seed plot. Risk of out crossing to other mm populations.
2005A020	half sibs of FC123mm (FC301); monogerm	05-FC1023m(iso)	05-FC1023m(iso) = Inc. 20021023(A,a a) mm; mm (A & aa) plants in bulk increase
2005A021	half sibs of FC123mm (FC301); multigerm	05-FC1023M(iso)	05-FC1023M(iso) = Inc. 20021023(A,aa) M_; M_ (A & aa) plants in bulk increase
2005A022	rzm-ER-%S [(C931aa x (FC907 x FC709-2)]F3 (20031022)	05-FC1022	= rzm-ER-% 20031022 (A,aa); 20031022 = [(C931aa x (FC907 x FC709-2)]F3; 47 MR increased in bulk after mild selection for rzm and CLS. Re-selected for size, shape, % sucrose. MR averaged 20.2% sucrose. Free of Erwinia after field inoculation (ER).
2005A023	C790-15cms x rhzm-ER-%S [(C931aa x (FC907 x FC709-2)]F3 (20031022)	05-FC1022H50	05-FC1022H50 = C790-15cms x rzm-ER-%S 20031022; 20031022 = [(C931aa x (FC907 x FC709-2)]F3 ;C790-15cms = mm, Rz1Rz1, ♀ tester, cms
2005A024	rzm-%-ER (C931 x FC709-2)F3	05-FC1018	05-FC1018 = rzm-%-ER 20031018(A,aa); FC20031018=(C931 x FC709-2)F3; 47 MR selected for resistance to rzm, CLS, Erwinia, %S, size, shape (see above). MR averaged 18.5% sugar.
2005A025	C790-15cms x [rhzm-%-ER (C931 x FC709-2)F3]	05-FC1018H50	05-FC1018H50 = C790-15cms x rzm-%-ER 20031018(A,aa); FC20031018=(C931 x FC709-2)F3; 47 MR selected for resistance to rzm, CLS, Erwinia, %S, size, shape (see above). MR averaged 18.5% sugar. C790-15cms = mm, Rz1Rz1, ♀ tester, cms
2005A026	rhzm-ER-%S (FC712 x 9931)F3	05-FC1019	05-FC1019 = rzm-ER-%S 20031019; FC20031019 = (FC712 x 9931)F3; 32 MR selected for resistance to rzm, CLS, Erwinia, %S, size, shape (see above). MR averaged 18.0% sugar.
2005A027	C790-15cms x [rhzm-ER-%S (FC712 x 9931)F3]	05-FC1019H50	05-FC1019H50 = C790-15cms x rzm-ER-%S 20031019; FC20031019 = (FC712 x 9931)F3; 32 MR selected for resistance to rzm, CLS, Erwinia, %S, size, shape (see above). MR averaged 18.0% sugar. C790-15cms = mm, Rz1Rz1, ♀ tester, cms

Table 6:

2005 2R Rhizoctonia root rot resistance evaluation of *Beta* PIs

Seed Source	Subspecies*	Donor's ID	DI**	% 0-1	% 0-3	AP 0-1	AP 0-3
941025	vulgaris	*(FC901/C817)//413 – 'SusCheck'*	4.3	12.4	24.2	18.1	25.7
831083	vulgaris	FC705/1 - 'Highly Resistant Check'	2.8	51.4	58.0	45.8	52.9
991017	vulgaris	FC703 - 'Resistant Check'	2.7	36.4	66.2	36.5	57.8
		LSD (P=0.05)	1.4			17.1	24.5
		Trial Mean..	5.5	10.1	20.1	10.6	21.5
PI 504182	*maritima*	Wild beet, Italy...	6.0	0.0	20.8	0.0	20.0
PI 504183	*maritima*	Wild beet, Italy...	6.5	2.0	8.4	3.7	10.9
PI 504184	*maritima*	Wild beet, Italy...	6.4	0.0	10.6	0.0	12.3
PI 504190	*maritima*	Wild beet, Italy...	5.8	9.5	18.0	12.8	20.9
PI 504193	*maritima*	Wild beet, Italy...	5.7	2.8	15.2	4.4	15.2
PI 504199	*maritima*	Wild beet, Italy...	6.2	0.0	12.4	0.0	18.3
PI 504202	*maritima*	Wild beet, Italy...	6.7	0.0	0.0	0.0	0.0
PI 504206	*maritima*	Wild beet, Italy...	7.0	0.0	0.0	0.0	0.0
PI 504223	*maritima*	Wild beet, Italy...	4.0	35.7	55.0	31.4	53.1
PI 504235	*maritima*	Wild beet, Italy...	7.0	0.0	0.0	0.0	0.0
PI 504237	*maritima*	Wild beet, Italy...	6.3	0.0	0.0	0.0	0.0
PI 504238	*maritima*	Wild beet, Italy...	nr				
PI 504239	*maritima*	Wild beet, Italy...	5.3	0.0	29.2	0.0	29.2
Ames 4436	*maritima*	Wild beet, Italy...	4.8	11.0	28.0	13.8	28.2
PI 504248	*maritima*	Wild beet, Italy...	5.5	4.0	14.0	5.3	14.3
PI 504253	*maritima*	Wild beet, Italy...	5.8	11.6	11.6	13.0	13.0
PI 504264	*maritima*	IDBBNR 5798, UK	6.6	0.0	5.8	0.0	6.5
PI 518304	*maritima*	IDBBNR 5814, UK	5.9	5.0	17.5	6.6	17.9
PI 518320	*maritima*	IDBBNR 5836, UK	5.5	9.5	18.3	12.4	24.8
PI 518342	*maritima*	IDBBNR 5927, UK	5.5	6.6	23.0	7.0	24.7
PI 518433	*maritima*	WB 817, France	6.0	5.0	9.6	6.0	11.7
PI 540566	*maritima*	WB 886, France	nr				
PI 540632	*maritima*	IDBBNR 5600, UK	4.5	25.0	34.5	22.5	32.0
PI 546403	*maritima*	IDBBNR 5637, UK	4.2	17.0	42.0	17.7	40.2
PI 546407	*maritima*	IDBBNR 5644, Greece.....................................	5.3	12.8	23.6	13.4	27.9
PI 546428	*maritima*	IDBBNR 3863, Ireland...................................	6.8	0.0	5.6	0.0	8.8
PI 604031	*maritima*	IDBBNR 9685, Greece, Aegean	6.1	3.6	15.6	7.0	20.0
PI 546518	*maritima*	IDBBNR 9675, Greece	6.6	2.8	7.2	4.4	10.0
PI 546508	*maritima*	Wild beet, Italy...	5.4	12.5	25.0	11.3	22.5
PI 504220	*maritima*	....	4.1	42.3	47.3	40.1	46.7

* Shown are the subspecies of *Beta vulgaris* examined.
** DI = Disease Index on a scale of 0 (no damage) to 7 (plant death), % 0-1= percent roots in class 0 and 1 combined, % 0-3 = percent roots in class 0 to 3 combined, AP is the arcsine-square root transformation of percentages of roots in classes 0-1 and 0-3 to normalize the data for analyses.
nr = not rated. These two lines had very poor emergence and not enough beets emerged for a meaningful rating. All analyses were performed without these two lines.

Table 7:

7R 2005 – Rhizoctonia Resistance Evaluation of USDA-ARS Fort Collins, CO (Lee Panella). FC710(4X) 1019 removed due to poor plant stand.							
Entry	Seed Source	Release Description	DI[1]	% Hlthy[2]	% 0 - 3[3]	Z%[4] Hlthy	Z% 0 - 3[4]
		LSD[5]	1.25			22.2	25.5
		CV	28.7			68.9	44.9
		Susceptible Check[6]	3.8	16	39	18.2	35.4
		Experiment Mean	3.5	24	51	25.5	45.0
		Resistant Check[7]	3.1	22	52	27.0	46.2
		Highly Resistant Check[8]	3.5	30	43	27.0	38.0
1021	20041010HO	FC712/MonoHy A4	2.4	45	68	41.7	56.1
1023	2004A008	EL51	2.4	40	76	35.9	61.7
1018	20041007	FC709-2	2.7	29	70	31.4	57.2
1022	20041010HO1	FC712/MonoHy A4 - CMS equivalent	2.8	32	64	34.0	53.3
1016	19961014	FC724 New Release 2003	2.9	35	63	34.8	53.6
1020	20011007	F3 (907 x 709-2) for RhzcR - hs 10A-	2.9	27	75	31.0	60.5
1011	19921019	FC729 – FC712/A4, 3 cycles Rhizoc,	2.9	35	59	35.7	53.2
1012	19951016HO	FC723 – EL44/FC708 mm	2.9	36	64	36.6	53.3
1015	19961010HO	FC722 – C718/FC708 New Release	3.5	9	56	11.3	48.7
1014	19961010HO1	FC722CMS – C718/FC708CMS	3.7	14	44	14.4	41.3
1013	19951016HO1	FC723CMS – EL44/FC708 CMS	3.9	12	44	13.4	38.2
1024	2004A029	04-FC1028; (9933rr x FC709-2)F3	4.1	10	37	16.8	37.1
1017	20001017	FC720 -- C718/(C718/FC708)	4.2	23	36	25.7	33.8
1026	20051011HO1	03-124CMS FC123 derivative	5.2	15	22	14.1	21.5
1025	20051011PF	03-124 FC123 derivative	5.7	5	15	9.6	20.0

[1]Disease Index is based on a scale of 0 (=healthy) to 7 (= plant dead).
[2]Percent of healthy roots (disease classes 0 and 1 combined).
[3]Percent of diseased roots likely to be taken for processing (disease classes 0 through 3 combined).
[4]Percentages were transformed to arcsin-square roots to normalize the data for analyzes.
[5]P=0.05; There were 6 missing plots, however LSD was estimated as if all plots were present.
[6]FC901/C817 - susceptible check
[7]FC703 - resistant check
[8]FC705/1 - highly resistant check

Table 8:

8R 2005 – Rhizoctonia Resistance Evaluation of USDA-ARS Salinas germplasm, CA (Bob Lewellen). Highly resistant control removed due to poor plant stand.							
Entry	Seed Source	Release Description	DI[1]	% Hlthy[2]	% 0 - 3[3]	Z%[4] Hlthy	Z% 0 - 3[4]
	(<4.11 significantly better than susceptible check)	LSD[5]	1.19			17.7	21.4
		CV	20.8			81.4	60.2
		Susceptible Check[6]	5.3	3	7	4.4	10.0
		Experiment Mean	4.5	14	28	17.0	28.7
		Resistant Check[7]	4.0	18	38	21.3	37.7
1069	03-FC1030-16	Inc.01-FC1030-16; Iso40	3.2	27	59	28.0	50.9
1068	03-FC1030-15	Inc.01-FC1030-15; Iso39	3.3	37	53	36.1	47.0
1064	CR411	RZM CR311, CR311AA x A; Sp10	4.1	22	38	22.5	34.0
1062	R421	RZM-ER-% R221; Iso9	4.1	20	34	24.0	32.2
1071	CR311-88	Inc.CR111-88(A,aa); Iso38	4.2	25	36	27.1	33.3
1073	03-FC1030-15H50	C790-15CMS x 01-FC1030-15	4.3	8	28	12.6	27.7
1067	04-FC1038	RZM-% FC20021038; Iso12	4.3	12	28	19.4	31.5
1074	03-FC1030-16H50	C790-15CMS x 01-FC1030-16	4.4	15	23	20.3	27.9
1076	Y491H74	03-FC1015HI x Y391	4.5	11	34	17.0	33.7
1066	04-FC1037	RZM-% FC20021037; Iso11	4.6	7	22	9.3	24.3
1061	Y475	RZM-ER-% Y275; Iso7	4.9	12	20	16.0	23.5
1065	04-FC1028	RZM-% FC20021028; Iso10	4.9	14	25	18.9	27.1
1063	4931	RZM 3931,3931aa x A; Sp8	5.1	8	21	10.1	24.9
1072	03-F1014-22	Inc. 01-FC1014-22(A,aa); Iso39	5.1	4	14	8.7	19.3
1075	Y491H76	03-FC1014-22HS x Y391	5.3	5	12	10.4	17.8
1070	4933-14	2933-14 aa xA; Sp4	6.3	2	2	3.7	3.7

[1]Disease Index is based on a scale of 0 (=healthy) to 7 (= plant dead).
[2]Percent of healthy roots (disease classes 0 and 1 combined).
[3]Percent of diseased roots likely to be taken for processing (disease classes 0 through 3 combined).
[4]Percentages were transformed to arcsin-square roots to normalize the data for analyzes.
[5]P=0.05; There were 6 missing plots, however LSD was estimated as if all plots were present.
[6]FC901/C817 - susceptible check
[7]FC703 - resistant check

Table 9:

5R 2005 – Rhizoctonia Resistance Evaluation of USDA-ARS Fort Collins Released Rhizoctonia Resistant Lines, CO (Lee Panella). Analyzed with PROC GLM and LSD values were calculated using 5 replications, although some plot values were lost. FC702, FC704, and FC705/1 were not analyzed because 3 or more of the 5 replications were lost.						
		DI[1]	% Hlthy[2]	% 0 - 3[3]	Z%[4] Hlthy	Z% 0 - 3
	LSD.	1.24			20.8	23.1
	CV.	30.2			56.6	38.2
FC201	2003A025	4.4	16	22	18.3	22.4
FC701	19931024	3.8	42	42	40.2	40.2
FC701-4	20021016	2.5	44	68	41.0	58.8
FC701-5	19721056	3.5	22	59	18.3	54.8
FC701-6	19801059H	2.5	44	74	41.4	60.1
FC702/2	19991016	3.4	21	49	24.0	44.4
FC702-4(4X)	20011009	3.7	20	52	23.9	49.3
FC702-6	19811055H	2.2	53	78	46.5	62.7
FC703	19991017	3.1	42	57	39.4	49.1
FC705	20001019	2.8	36	70	36.8	57.9
FC706	20001020	3.2	22	55	26.8	48.5
FC707	20001021	3.8	22	36	24.8	33.6
FC708	19831085HO	3.6	13	47	13.9	40.4
FC709	19991018	2.6	48	68	43.6	55.9
FC709-2	20041003	2.5	35	77	32.8	64.4
FC710	19941024	2.4	40	78	38.6	62.9
FC710(4X)	19971017	3.5	13	58	11.3	53.8
FC711	19821087	3.9	15	51	18.0	45.4
FC712	19881032H	2.3	41	83	36.7	74.0
FC712(4X)	19971018	3.1	36	51	33.8	46.0
FC715	19911026HO	2.8	39	66	35.4	55.0
FC716	19971019	3.3	26	52	29.7	46.3
FC717	19981025	5.4	6	13	7.5	11.3
FC718	19911032	3.0	27	63	25.2	53.5
FC719	19911037	2.9	41	59	39.1	51.2
FC720	19961015	2.3	45	82	42.1	68.1
FC721	19931005HO	3.5	15	52	19.2	46.2
FC721CMS	19931005HO1	3.4	21	55	24.4	48.2
FC722	19961010HO	4.0	8	44	7.9	40.7
FC722CMS	19961010HO1	3.5	27	55	25.0	50.9
FC723	19951016HO	3.1	26	64	27.8	53.9
FC723CMS	19951016HO1	2.6	35	73	33.3	59.5

5R 2005 – Rhizoctonia Resistance Evaluation of USDA-ARS Fort Collins Released Rhizoctonia Resistant Lines, CO (Lee Panella). Analyzed with PROC GLM and LSD values were calculated using 5 replications, although some plot values were lost. FC702, FC704, and FC705/1 were not analyzed because 3 or more of the 5 replications were lost.

		DI[1]	% Hlthy[2]	% 0 - 3[3]	Z%[4] Hlthy	Z% 0 - 3
	LSD.	1.24			20.8	23.1
	CV.	30.2			56.6	38.2
FC724	19961014	2.7	42	61	40.3	51.9
FC725	19921008	1.9	65	79	56.8	66.3
FC726	19931010	3.2	41	57	36.4	46.8
FC727	19951017	2.6	37	73	37.5	59.5
FC728	19921025	2.6	47	63	43.0	53.1
Susc. Check	19941025	**5.7**	**2**	**4**	**3.5**	**7.2**
FC703	19991017	3.4	27	47	30.6	43.4

[1]Disease Index is based on a scale of 0 (=healthy) to 7 (= plant dead).
[2]Percent of healthy roots (disease classes 0 and 1 combined).
[3]Percent of diseased roots likely to be taken for processing (disease classes 0 through 3 combined).
[4]Percentages were transformed to arcsin-square roots to normalize the data for analyzes.

BSDF PROJECT 441 – CERCOSPORA LEAF SPOT RESEARCH AND BREEDING FOR CERCOSPORA AND CURLY TOP RESISTANCE

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JUSTIFICATION FOR THIS RESEARCH:

This element of the breeding program at Fort Collins is devoted to the development of germplasm with resistance to more than one sugar beet disease and improved agronomic characteristics. It is built on germplasm developed at Fort Collins over the last fifty years for combined resistance to Cercospora leaf spot and the curly top virus. This is an integrated breeding program with greenhouse and laboratory studies, and a field program based on testing in an artificial epiphytotic created in the unique Fort Collins environment. It involves close collaboration with the other USDA-ARS sugar beet programs in the U.S. and sugar beet seed industry customers. The major goals of this program are: 1) the development of sugar beet germplasm with resistance to more than one disease and excellent agronomic characteristics; 2) the improvement of breeding techniques, traditional and molecular, to develop this germplasm; and 3) an increased understanding of the sugar beet/pathogen interactions to improve management practices of these diseases in sugar beet production areas. Genetic information developed during this research will be used to execute additional cycles of pathogen inoculation, plant selection, and recombination among germplasms that we have in our leaf spot improvement program. Results of these tests will be the basis of decisions about specific germplasm, i.e., retain, discard, recombine, release, etc. Germplasms likely to be useful for variety improvement will be identified and released for use by other sugar beet breeders.

Increased resistance to *Cercospora* continues to be an extremely important goal. The need for fungicides would be greatly reduced, if the level of resistance available in most Cercospora-resistant experimental lines were present in commercial hybrids (along with good sugar and seed yield). That continued improvement in genetic resistance to this serious pathogen still is needed, is evident by the occurrence of *Cercospora* strains that are resistant or increasingly tolerant to our most potent fungicides. Additionally, some of these fungicides may be removed from the market because of their perceived or real threat to the environment. In many areas where Cercospora leaf spot is a problem, the curly top virus also causes significant losses. And, there are some growing areas in which combined resistance to Cercospora leaf spot, Rhizomania, curly top, Rhizoctonia root rot, and other diseases are desirable. Germplasm is needed with combined resistance to these diseases, along with good combining ability for yield components.

2005 Field Research on Cercospora Leaf Spot of Sugar Beet

The breeding program in Fort Collins has created an annual artificial epiphytotic through inoculation with *Cercospora beticola* for over forty years. This epiphytotic has been used to evaluate and select for resistance to leaf spot caused by *C. beticola*. We have been pleased to participate in and lead this cooperative research project between the ARS, Colorado State University, and the BSDF. Because of the difficulty in getting good epiphytotics in our semi-arid climate, we are working with Mitch McGrath to relocate the Cercospora screening nursery to Michigan this summer (2006).

This year we lost the nursery in Akron, due to herbicide carry over from previous crops. The results for some of the experiments in Yuma, CO are included, but they were marginal at best, with significant differences in some of the experiments but not enough spread between resistant and susceptible genotypes to get good separation in others. Yuma, in 2005, had high temperatures, and Cercospora was late to develop. We did not have conditions conducive to Cercospora leaf spot development until late August and started rating in September. Four ratings were taken in September, but disease was not particularly high. The highest rating in the Cercospora field was a 6 (scale of 0-10).

Cercospora/Curly Top-Resistant Populations with Resistance to Multiple Sugar Beet Diseases and Superior Agronomic

Germplasm under Development:

Cercospora Leaf Spot/Curly Top Resistant (LSR/CTR) Breeding Populations Currently Under Development.

FC301 Population and Sib Lines:

1. Cercospora leaf spot and curly top resistant monogerm base population from a polycross of FC607 and FC604 with two Salinas germplasms 2859 and 2890 **(Tested in Salinas as FC123).**
   a) 2890 (sp) = 0790 *mm aa* x 1890 (Salinas); is seed from *aa* plants open pollinated by A- plants. 0790 = population-790 cycle 5 synthetic by S_1 progeny, *aa*, mm, O-type, good combining ability, adapted to California, S^f. 1890 = BC population to population 790 to get Rz equivalent, remains variable for M-:mm, Rz-:rzrz, etc.
   b) 2859 m (sp) = 1859, 1859R aa x A- (Salinas); Released in 1992 as C859. S^f, similar to 2890, but should have higher curly top resistance. Segregates and variable for M-:mm, Rz-:rzrz, A-:aa, predominant background is lines like C563.
2. Cercospora leaf spot and curly top resistant multigerm base population from a polycross of FC902 with two Salinas germplasms 278 and 4918.
   a) 278 (Iso 83) = RZM R078; R278 is Rz (segregates Rz--:rzrz) version of C46. It should be S^sS^s, MM.
   b) 4918 (sp) = RZM 3918aa X A-, 142 aa plants; This is an increase of released material C918. It should be Multigerm, over 75% S^f and segregating for A-, R-, Rz-, VY, CT, Erw, & PM.
3. 20021037; (Best FC LSR x Best EL LSR) x CR011 (Salinas LSR/RhzmR) [(20011001 x 2001A031)blk F_2] – tested in Salinas as 04-FC1037.
   a) Salinas CR9110 = more broad based rhizomania and leaf spot resistant population, will segregate A- and S^f-.
   b) 20011001 = (Best Fort Collins leaf spot resistant x Best East Lansing leaf spot resistant), population cross and bulk made using hypocotyl color.

FC301 Population and Sib Lines: (cont.)

4. 20021038; (Best FC LSR and EL LSR) x CR910 – [(20011001 x 2001A032)blk F_2] – tested in Salinas as 04-FC1038.
   a) Salinas CR910 = fairly inbred rhizomania and leaf spot resistant population, will segregate A- and S^f-.
   b) 20011001 = (Best Fort Collins leaf spot resistant x Best East Lansing leaf spot resistant), population cross and bulk made using hypocotyl color.
5. Seed from FC709-2 x FC907 was sent to Larry Campbell at Fargo to cross to Sugar beet root maggot resistant germplasm to develop a population that will produce pollinators with resistance to Rhizoctonia, Cercospora, and Root maggot.

PROGRESS IN 2005:

We were unable to obtain good data on advanced breeding lines of *Cercospora* resistant germplasms in the ARS leaf spot nursery at Yuma. These lines will be replanted this year, either in Fort Collins, Shakopee, or East Lansing. They are part of the resistant germplasm development effort in which a new germplasm should be released from the "pipeline" every two to four years. The above populations currently are in different stages of development.

1. FC301 was released from this population; other selections from ½ sib progeny rows based on combined leaf spot and curly top resistance (FC607&FC604/2859&2890) of the monogerm (FC123mm) and multigerm (FC123MM) population were planted in the 2003 mother root nursery for increase. Material sent to Salinas, CA and showed good rhizomania resistance and progeny families have been selected sucrose. Sib-lines to FC301 that have undergone reselection for resistance to Cercospora leaf spot are being increased for release in 2006 or 2007. Selected material from Salinas has been returned to Fort Collins for evaluation, crossing and selection (see table in 440 report).
2. Plants (F2) from the CTR/LSR multigerm cross (2 above – FC902/278/4918) were tested for resistance to Rhizoctonia and Cercospora and recombined.
3. Seed of 04-FC1037 was received from R.T. Lewellen in Salinas after selection for sucrose and rhizomania and will be evaluated for Cercospora resistance. Half-sib families of (Best FC LSR x Best EL LSR) were grown in the cercospora nursery and selections were made and recombined for further testing (see table).
4. Seed of 04-FC1038 was received from R.T. Lewellen in Salinas after selection for sucrose and rhizomania and will be evaluated for Cercospora resistance.
5. Seed from (FC709-2 x FC907)F_2 has been sent to Larry Campbell at Fargo to cross to Sugar beet root maggot resistant germplasm and be selected for Cercospora resistance. Sib lines were selected this year for Cercospora resistance and recombined. The seed is being sent to Fargo for root maggot screening. The resulting population will provide pollinators with resistance to Rhizoctonia root rot and the sugar beet root maggot.

Table 10:

2005 LEAF SPOT FIELD PLANTING PLAN
Experiment 7A, 2005
Selections from Cercospora Nursery in Yuma, CO

Variety and/or description						
20041013-xhs – EL & FC LSR polycross – monogerm				MEANS		
Seed Number	Plot No.	Plot No.	Entry No.	9/14/05	9/21/05	9/28/05
20041013-14	2474	2672	544	0.5	1.0	1.0
20041013-20	~~2478~~	2676	548	1.0	1.0	1.0
20041013-3	2487	2685	557	0.5	1.0	1.5
20041013-48	2502	2700	572	0.5	1.0	1.5
20041013-62	2511	2709	581	1.0	1.0	1.0
20041013-68	2518	2716	588	1.0	1.5	1.5
20041013-75	2525	2723	595	1.0	1.0	1.5

20041014-xhs – EL & FC LSR polycross – multiger				MEANS		
Seed Number	Plot No.	Plot No.	Entry No.	9/14/05	9/21/05	9/28/05
20041014-01	2556	2754	626	0.5	2.0	1.5
20041014-07	2563	2761	633	1.0	1.0	1.0
20041014-17	2572	2770	642	1.0	1.0	1.0
20041014-21	2576	2774	646	1.0	1.5	1.0
20041014-38	2592	2790	662	1.0	1.5	1.0
20041014-54	2607	2805	677	1.5	1.5	1.0
20041014-57	2610	2808	680	1.0	1.0	2.0
20041014-62	2614	2812	684	1.0	1.0	1.5
20041014-71	2625	2823	695	1.5	1.0	1.5
20041014-74	2628	2826	698	1.0	1.0	2.0

Table 11:

2005 Curly Top Nursery in Kimberly, ID- USDA-ARS Plant Introductions							
						23-Aug	13-Sep
Entry	Seed	ID			LSD 0.05	ns	ns
					CV	16.1	15.2
31	**1996A008**	**Beta G6040**	***vulgaris***	**Resistant Check**		**3.0**	**4.0**
1	Ames 4436		*maritima*		annual	4.5	5.0
4	PI 504184		*maritima*	Italy	annual	4.5	5.5
20	PI 518433	IDBBNR 5927	*maritima*	UK, England	annual	4.5	5.5
8	PI 504200		*maritima*	Italy	annual	4.5	5.5
21	PI 540566	WB 817	*maritima*	France	annual	4.0	5.5
17	PI 504253		*maritima*	Italy	annual	4.5	5.5
19	PI 518304	IDBBNR 5798	*maritima*	UK, England	annual	5.0	6.0
2	PI 504182		*maritima*	Italy	annual	4.0	6.0
3	PI 504183		*maritima*	Italy	annual	4.5	6.0
15	PI 504238		*maritima*	Italy	annual	4.5	6.0
12	PI 504223		*maritima*	Italy	annual	4.0	6.0
14	PI 504237		*maritima*	Italy	annual	5.0	6.0
7	PI 504197		*maritima*	Italy	annual	4.5	6.5
18	PI 504264		*maritima*	Italy	annual	4.5	6.5
13	PI 504235		*maritima*	Italy	annual	4.5	6.5
10	PI 504213		*maritima*	Italy	annual	5.0	7.0
9	PI 504202		*maritima*	Italy	annual	5.0	7.0
16	PI 504239		*maritima*	Italy	annual	5.0	7.0
11	PI 504220		*maritima*	Italy	annual	4.0	7.0
29	PI 562601	IDBBNR 9750	*maritima*	Egypt, Matruh	annual	5.0	7.0
22	PI 540632	WB886	*maritima*	UK, England	annual	4.5	7.0
23	PI 546403	IDBBNR 5600	*maritima*	UK, England	annual	6.0	7.0
28	PI 562600	IDBBNR 9749	*maritima*	Egypt, Matruh	annual	5.0	7.0
27	PI 562591	IDBBNR 9742	*maritima*	Egypt, Matruh	annual	4.5	7.0
25	PI 546508	IDBBNR 9687	*maritima*	Greece,	annual	5.5	7.5
5	PI 504190		*maritima*	Italy	annual	5.5	8.0
6	PI 504193		*maritima*	Italy	annual	5.5	8.0
30	PI 562604	IDBBNR 9753	*maritima*	Egypt, Matruh	annual	5.0	8.0
32	**19911032**	**FC718**	***vulgaris***	**Suscep. check**		**7.0**	**8.0**
24	PI 546508	IDBBNR 9675	*maritima*	Greece	annual	4.5	8.5
26	PI 562586	IDBBNR 9737	*maritima*	Egypt, Matruh	annual	6.0	9.0

Table 12:

Experiment 4A, 2005. Leaf Spot Evaluation of USDA-ARS Salinas contributed lines.				
		Disease Index[1]		
Entry	**Identification**	**September 14th**	**September 21st**	**September 28th**
	$LSD_{0.05}$	**1.25**	**1.47**	**1.07**
449	**LSS[2] (931002)**	**3.0**	**3.0**	**4.0**
450	**LSR[3] (821051H2)**	**1.0**	**1.8**	**3.3**
Trial Mean		**1.9**	**2.5**	**3.2**
421	Monohikari	2.7	3.0	4.3
422	Beta 4430R	5.0	5.8	6.3
423	03-SP 22-0	1.7	2.3	2.7
424	Y 475	2.3	3.2	3.7
425	R 421	3.3	3.5	3.7
426	Z 425	1.7	2.7	4.2
427	4 931	2.0	3.2	4.0
428	4 941	2.7	4.3	4.3
429	CR 411	1.7	2.7	2.7
430	N 412(sp)	1.7	2.2	2.7
431	N 472(sp)	2.2	2.7	3.0
432	04- FC1028	1.3	2.0	3.0
433	04- FC1037	1.3	2.0	2.7
434	04- FC1038	1.3	1.3	3.0
435	4951 -210	1.5	2.0	2.3
436	03-FC 1030-15	1.8	2.7	3.7
437	03-FC 1030-16	2.0	2.0	2.8
438	CR410 -203	1.7	2.0	2.7
439	4933 -14	1.0	2.0	2.0
440	4933 -14H50	2.3	2.7	3.3
441	CR410 -231	1.0	2.0	2.7
442	CR412 -211	2.5	3.0	4.3
443	CR412 -5	2.2	3.0	3.2
444	CR311 -88	1.7	1.7	3.0
445	CR311 -6	1.3	1.5	2.0
446	CR311 -41	1.3	1.7	2.3
447	03-F1014 -22	1.3	2.0	2.3
448	03-FC123 -31	1.3	2.0	3.0

[1]Disease Index is based on a scale of 0 (=healthy) to10 (=dead).
[2]The Leafspot Susceptible Check is SP351069-0.
[3]The Leafspot Resistant Check is ((FC504CMS x FC502/2) x SP6322-0).
Means and LSD values were calculated with missing data. Lines 335, 340, and 342 were two reps rather than three.
LSD and experimental mean values also were calculated with an additional nine entries

Table 13:

Experiment 6A, 2005. Leaf Spot Evaluation of USDA-ARS Fargo, ND contributed lines.					
		Disease Index[1]			
Entry	**Identification**	**September 7th**	**September 14th**	**September 21st**	**September 28th**
	$LSD_{0.05}$	**0.79**	**N.S.**	**N.S.**	**1.28**
532	**LSS[2] (941027)**	**1.5**	**1.7**	**3.7**	**4.0**
533	**LSR[3] (821051H2)**	**0.8**	**1.2**	**1.5**	**1.8**
Trial Mean		**0.8**	**1.3**	**1.9**	**2.5**
521	01 N0060	0.5	1.2	2.3	2.0
522	99 N0043	1.0	1.0	2.2	2.8
523	97 N0035	0.3	1.0	1.3	2.0
524	03 N0039	0.5	1.3	1.8	2.7
525	02 N0024	1.5	1.3	2.0	2.0
526	03 N0030	0.3	1.2	1.2	2.3
527	03 N0032	0.8	1.0	1.7	3.5
528	03 N0033	0.7	1.3	1.7	2.0
529	03 N0036	1.0	1.5	1.8	2.7
530	03 N0105	0.7	1.3	2.0	2.0
531	03 N0106	1.3	1.7	1.7	2.5

[1]Disease Index is based on a scale of 0 (=healthy) to10 (=dead).
[2]The Leafspot Susceptible Check is SP351069-0.
[3]The Leafspot Resistant Check is ((FC504CMS x FC502/2) x SP6322-0).
N.S. - not significantly different, α=0.05

BSDF PROJECT 443 – PRE-BREEDING: THE INTROGRESSION OF NEW SOURCES OF CERCOSPORA LEAF SPOT RESISTANCE FROM *BETA VULGARIS* SSP. *MARITIMA* AND OTHER EXOTIC SOURCES INTO SUGAR BEET-TYPE POPULATIONS

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A major emphasis of the research mission of the USDA-ARS plant scientists is the collection, documentation, characterization, evaluation, regeneration (maintenance), distribution, and utilization of plant germplasm, especially Plant Introduction (PI) accessions in the USDA-ARS National Plant Germplasm System (NPGS). The Sugar Beet Research Unit at Fort Collins is coordinating the national program for *Beta* germplasm evaluation. In addition to the evaluation for Rhizoctonia and Cercospora resistance, it is crucial that the ARS scientist be involved in the long rang, high risk research problems involved in sugar beet 'germplasm enhancement' or 'pre-breeding' from exotic germplasm or wild relatives. This is an important component in the overall sugar beet improvement effort of the Fort Collins Sugar Beet Research Unit.

JUSTIFICATION FOR THIS RESEARCH:

Cercospora leaf spot (caused by the fungus *Cercospora beticola* Sacc.) is one of the most widespread diseases of sugar beet and is a serious problem in many sugar beet production areas throughout the U.S. The disease damages the leaves, which, consequently, reduces root yield, percent sucrose of roots, and purity of the extracted juice. Cercospora leaf spot currently is controlled by combining spraying with commercial fungicides and the use of disease tolerant germplasm. The development of Cercospora leaf spot resistant sugar beet lines and hybrids with greater levels of host-plant resistance offers a more sustainable solution to this disease problem.

If the level of resistance available in some Cercospora-resistant experimental breeding lines were present in commercial hybrids (**along with good sugar and seed yield**), the need for fungicides could be greatly reduced. That continued improvement in genetic resistance to this serious pathogen is still needed is evident by the occurrence of *Cercospora* strains that are tolerant to our most potent fungicides. Additionally, some fungicides may be removed from the market because of their perceived or real threat to the environment.

Finally, the gene pool for resistance to Cercospora leaf spot is extremely narrow. Many of the resistant lines are highly inbred, therefore, closely related to one another, and stem from germplasm coming out of Italy in the early 1900s. In the germplasm developed at Fort Collins, continued inbreeding has increased the level of disease resistance, but at the cost of plant vigor. Over the long term, a secure, sustainable response to this disease requires commercial quality hybrids with good host-plant resistance.

SUMMARY OF LITERATURE REVIEW:

Cercospora leaf spot (CLS) has been an intermittent problem in sugar beet growing areas of the United States where the summers can be hot and humid (Red River Valley, Michigan, Ohio, and, less often, Great Plains growing areas and California). It has been estimated that a severe epidemic can cause up to a 42% loss of gross sugar (Smith and Martin, 1978; Smith and Ruppel, 1973), or up to a 43% relative dollar loss (Shane and Teng, 1992).

Resistance to CLS has long been a goal of the USDA-ARS sugar beet research program at Fort Collins and researchers there developed the techniques necessary to manage the screening nurseries in such a way as to promote the development of the disease (Ruppel and Gaskill, 1971). A careful crop rotation (sugar beet-barley-barley-barley-sugar beet) and the arid climate and low relative humidity have allowed this to be done in such a manner that there are rarely high enough levels of any other disease present in the leaf spot nursery to confound the results. The resistance to CLS could more accurately be described as a tolerance, rather than true resistance. Tolerance or "field resistance" means that, although some symptoms of the disease are present, the plant still is able to perform well (Fehr, 1987 p.307).

Much of the Cercospora-resistant germplasm in use today came out of Munerati's program in Italy, in which B. vulgaris spp. maritima was the source of resistance genes (Lewellen, 1992). In this genetic source, there are an estimated 4 or 5 genes responsible for CLS resistance (Smith and Gaskill, 1970) and broad-sense heritability estimates ranged from 12 to 71% (Bilgen et al., 1969). Narrow-sense heritability estimates of about 24% compared well with realized heritability values, and 44 to 62% of the variation was due environment in this test (Smith and Ruppel, 1974). The large environmental variation has made it difficult to make progress in developing resistance through mass selection. Incorporation of high levels of leaf spot resistance into varieties with superior agronomic performance also is difficult (Smith and Campbell, 1996) and, therefore, commercial resistant varieties require some fungicide application to provide adequate levels of protection against Cercospora (Miller et al., 1994).

A major problem in the development of CLS-resistant sugar beet is the loss of vigor due to the continual inbreeding. Coons (1955) noted this and it has been a concern ever since (McFarlane, 1971). The use of hybrid varieties has ameliorated this problem to some extent, but seed production on the highly inbred O-type males and CMS females still is a problem. This creates an urgent need to continue to develop a broader genetic base in our CLS-resistant germplasm than we have today. Also as commercial hybrid parents become more inbred, the germplasm base from which these inbred parents are developed must have the diversity necessary to provide for maximum gain through heterosis. In addition to broadening the genetic base of the commercial sugar beet germplasm, novel genes for resistance to CLS might lead to transgression of the currently available tolerance to CLS. Simply defined, transgression is when a population contains individuals with a phenotype that is beyond the phenotype found in the parents of the population (de Vicente & Tanksley, 1993).

The USDA-ARS National Plant Germplasm System Beta collection has over 2,000 Plant Introduction (PI) accessions. The germplasm used most often in sugar beet breeding is from Beta vulgaris spp. vulgaris, which includes all of the biennial sugar beet types, or from Beta vulgaris spp. maritima, which contains the closely related wild sea beet and has both annual and biennial types. Germplasm with a biennial flowering habit is easier both to introgress and screen. Beta vulgaris spp. maritima has, nonetheless, been used as a source of resistant germplasm. Much of the CLS-resistant germplasm in use today, which came out of Munerati's program in Italy, had B. vulgaris spp. maritima as the source of resistance genes (Lewellen, 1992). There have been very few new efforts to locate and incorporate other sources of resistance to Cercospora into this narrow germplasm base. Munerati's success, and the research of others, has shown that it can be done if we have the persistence to do it (Bilgen et al., 1969; Doney, 1993; Lewellen, 1995).

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OBJECTIVES:

1. The formation of long range breeding populations through the introgression of Cercospora resistant germplasm from "exotic" sources (Beta vulgaris ssp. maritima, fodder beet, foreign sugar beet landraces from the PI collection, etc.).
2. The development of germplasm populations from these long range populations that are of sufficient agronomic quality to be of use to commercial breeders. They will be a source of leaf spot resistance with different genetic backgrounds.
3. The development of techniques (both traditional and molecular) to more efficiently introgress the exotic germplasm into sugar beet breeding populations.

MATERIALS AND METHODS:

Artificial field inoculation with Cercospora beticola and leaf spot scoring will be used to identify the resistant germplasm sources and make selections in the developing populations. The exotic materials will be crossed into sugar beet populations that have been selected for agronomic quality (recoverable sucrose yield). These sucrose populations are based on old commercial varieties – i.e., MonoHy T6, A7, A4 and breeding lines from American Crystal Sugar Co. and Seedex, Inc. – and USDA-ARS developed germplasm such as L-19 (WC9127OM) and East Lansing smooth root germplasm , SR87. Other parents include high sucrose germplasm from Poland and other Eastern European countries. Salinas parent '3859' was used to produce populations that are self-fertile (S^f) and segregating for nuclear male sterility (A-:aa).

Hybrid populations will be handled in the following manner: 1) Following the initial cross, a population will be random mated (using aa females because of the self-fertility) for three to four generations to break up linkage groups and remove annual plants. 2) Sugar beet-type mother roots will be selected, selfed, and progeny tested for agronomic performance and disease resistance. 3) Selected roots will be recombined (and backcrossed if desirable) and re-selected until they ready for release. Advanced populations will be released to the sugar beet seed industry.

TIME LINE OF ANTICIPATED ACCOMPLISHMENTS:

Development of a resistant germplasm line generally takes seven years. A longer time will be necessary to incorporate disease resistance from more exotic sources. Because this is a new program, it will take time for the first germplasm to make it through the process. Once that happens, there will be a "pipeline" of germplasm in various stages of development and the release of new germplasm will occur every two to four years. The incorporation of exotic sources into agronomically acceptable germplasm is a long term proposition - results will not appear overnight. This is the type of long-term germplasm development that ARS is well suited to perform.

RESEARCH PROGRESS 2005:

We are working with the eighteen populations listed below (Table 14) and have increased or made crosses in these populations. All of the male parents are germplasm that have been identified as having resistance to *Cercospora beticola* (causal agent of Cercospora leaf spot). The female parents are from a population developed to have high sucrose yield potential. These sucrose populations are based on old commercial varieties – i.e., MonoHy T6, A7, A4 and breeding lines from American Crystal Sugar Co. and Seedex, Inc. – and USDA-ARS developed germplasm such as L-19 (WC9127OM) and East Lansing smooth root germplasm , SR87. Other parents include high sucrose germplasm from Poland and other Eastern European countries. Salinas parent '3859' was used to produce populations that are self-fertile (S^f) and segregating for nuclear male sterility (*A-:aa*). The families from various crosses are in different stages of development and evaluation. At the F_3 stage, when sufficient seed is available, we are beginning field screening and selection. Seed of these families has been bulk increased and is beginning to be evaluated. All of the early generation populations show some annual plants in our environment.

We are re-crossing some of those from which we obtained insufficient F_1 seed. Plants from those populations producing some biennial plants are being vernalized for 90 days and the populations are being increased (i.e., random mated using the genetic male sterility where possible). The annuals will be handled in a similar fashion once the F_1 populations have been increased. All will be cycled through at least three cycles of random mating.

Half-sib progeny families were created for 20051002, 20051003, 20051004 and 20051005. These families will be selected in an artificial epiphytotic this summer and recombined and tested for release in 2007. 20051001 and 20051006 were planted in the mother root nursery in 2005 and bulk increased. They will be replanted in the 2006 mother root nursery to produce roots for half-sib family selection. The seed sources of these lines will be planted in both the Cercospora nursery (either in Fort Collins, East Lansing or Shakopee) and curly top nursery. Those lines in the shaded areas of the table below will be increased in either the greenhouse or mother root nursery.

Table 14. List of germplasm used in developing Cercospora leaf spot resistant populations and the stage of each of the populations. Those populations highlighted have been increased.

♀ parent	Donor (♂) Designation	Name or Origin (♂)	% Bolting (♂) no induction 1996 FC, CO	F_1 Population	F_2 Population	F_3 Population	F_4 Population	F_5 Population	F_6 Population
961005	PI 535826	Giant Poly	20%	971021H2	981031	991026	20011027MS	20031013	<u>20051002</u>
961005 19991024H2	PI 535833	Saturn	0%	--- 20031001H2					
961005	PI 540593	WB 847	0%	971023H2	20021026	<u>20051001</u>			
961005	PI 540596	WB 850	70%	971024H2	981032	20011002bbPF 20011002bbMS 20011002B-	<u>20051004</u>		
961005	PI 540605	WB 859	25%	971025H2	20011054	20031014	<u>20051005</u>		
961005	PI 535843	PN MONO 1	100%	971026H2[1]					
961005	PI 540575	WB 829	100%	971027H2[2]					
961005	PI 540599	WB 853	50%	971028H2	981033	20011045bbPF 20011045bbMS	<u>20051003</u>		
961005	BGRC #32375 (*B. v. maritima*)	Greece	annual	971029H2	20011036				
961005	BGRC #36538 (*B. v. maritima*)	Greece	annual	971030H2[3]	20011037				
851046HO	BGRC #45511 (*B. v. maritima*)	Greece	annual	981001H3	20011038B_ 20011038bb	shelved – use 20051006			
961005 19991024H2	BGRC #45511 (*B. v. maritima*)	Greece	annual	--- 2001046H2	20021036B_ 20021036bb	<u>20051006</u>			
851046HO	*BGRC* #45516 (*B. v. maritima*)	Greece	annual	981002H3	20011039B_ 20011039bbPF 20011039bbMS				
961005 19991024H2	*BGRC* #45516 (*B. v. maritima*)	Greece	annual	--- 20021033H2					

Table 14. List of germplasm used in developing Cercospora leaf spot resistant populations and the stage of each of the populations. Those populations highlighted have been increased.

♀ parent	Donor (♂) Designation	Name or Origin (♂)	% Bolting (♂) no induction 1996 FC, CO	F_1 Population	F_2 Population	F_3 Population	F_4 Population	F_5 Population	F_6 Population
961005	BGRC #48810 (*B. v. maritima*)	Tunisia	annual	19981003H2	20011040B_ 20011040bb	20021030B_ 20021030bb	20031038bb		
851046HO	BGRC #48810 (*B. v. maritima*)	Tunisia	annual	981003H3	200110141B_ 200110141bb				
961005	BGRC #48819 (*B. v. maritima*)	Tunisia	annual	981004H2	20011042B_ 20011042bb	20021031B_ 20021031bb	20031039B_ 20031039bb		
961005 19991024H2	BGRC #48819 (*B. v. maritima*)	Tunisia	annual	--- 20021034H2					
961005 19991024H2	BGRC #51430 (*B. v. maritima*)	Greece	annual	--- 20021035H2					

[1]Only 16 seed balls produced.
[2]Only 10 seed balls produced.
[3]Only 60 seed balls produced.
Light shading into GH/mother root nursery in 2006/07
Underlined seed productions produced in 2005 – into testing in 2006.

SUGARBEET RESEARCH
TEXAS AGRICULTURAL EXPERIMENT STATION
BUSHLAND, TEXAS

2005 REPORT

SECTION C

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This research was supported in part by funds provided through the Beet Sugar Development Foundation. (Projects 620, 621, 622, 650 and 651)

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PUBLICATIONS

Abstract of Papers Presented or Published

Haagenson, D. M., Klotz, K. L., McGrath, J. M. 2006. Sugarbeet sucrose synthase genes differ in organ-specific and developmental expression. Journal of Plant Physiology. 163:102-106.

A full-length sucrose synthase (SBSS2) cDNA clone was isolated from sugarbeet and its structure, organ specific expression and developmental expression were characterized and compared to a previously isolated sugarbeet sucrose synthase gene (SBSS1). The two genes share 80% similarity in amino acid sequence but belong to different sucrose synthase subclasses based on phylogenic analysis. Both sucrose synthases were highly expressed in roots, and had low levels of expression in leaf tissue. Transcript abundance of SBSS2, relative to SBSS1, was greater in young vegetative tissues and reduced in mature tissue. Sucrose synthase protein accumulation mirrored steady-state mRNA levels suggesting that organ and developmental specific expression of sugarbeet sucrose synthase protein is largely regulated at the level of transcription.

Klotz, K. L., Haagenson, D. M. 2005. Sugarbeet sucrose synthase gene expression is organ-specific, developmentally regulated, and affected by abiotic stresses [abstract]. Annual Meeting Abstracts [CD ROM]. Madison, WI ASA-CSSA-SSSA.

Sucrose synthase is the predominant sucrose degrading activity in sugarbeet (Beta vulgaris L.) root and is believed to have roles in carbohydrate partitioning to the root during production and sucrose loss during storage. Two genes, sugarbeet sucrose synthase 1 (SBSS1) and sugarbeet sucrose synthase 2 (SBSS2), contribute to sucrose synthase activity in sugarbeet root. To improve our understanding of sucrose synthase expression and the factors that control it, the organ-specific and developmental expression of these two genes and their responses to environmental factors were determined. SBSS1 and SBSS2 exhibited high transcriptional expression in roots and low transcriptional expression in leaves. In floral tissues, SBSS1 and SBSS2 exhibited low and moderate levels of expression, respectively. In the root, SBSS1 transcripts were evident at all developmental stages, with greatest transcript abundance during mid-season growth. SBSS2 transcript levels were greatest during early root development and were expressed at very low levels during late season growth. SBSS1 and SBSS2 protein levels generally reflected changes in transcript abundance, although changes in protein abundance were greatly delayed from transcriptional changes. Abiotic stresses had different effects on the steady state transcript levels of the two genes. SBSS1 transcript levels increased in response to anoxia and wounding, were unaffected by cold temperature, and reduced in response to

harvest. SBSS2 transcript abundance increased in response to cold temperature and wounding and declined in response to harvest and anoxic conditions. Transcriptional changes in expression due to abiotic stresses did not correspond to similar changes in protein levels or enzyme activity. The differences between transcript abundance, protein abundance and enzyme activity suggest that protein stability and posttranscriptional regulation of expression may be important determinants of sucrose synthase activity in sugarbeet root.

Weiland, J. J., McGrath, J. M. 2006. An EST database of the sugarbeet pathogen Aphanomyces cochliodes. Plant & Animal Genome Conference. Abstract No. W181:48.

Seedling black root and adult root rot caused by the oomycete Aphanomyces cochlioides are perennial problems to sugarbeet production in warm, wet environments. Although genetic resistance in sugarbeet can be used to ward off mild infections of adult plants by the organism, heavy disease pressure cannot be tolerated; seedlings can only be protected by a single, registered fungicide. An expressed sequence tag (EST) database was created to examine the interaction of A. cochlioides with the sugarbeet host. A. cochlioides growing in nutritionally rich artificial medium, in nutritionally lean artificial medium, and invading seedlings of a susceptible sugarbeet hybrid variety was used to produce cDNA libraries. One thousand five hundred single-pass sequence reads were performed on clones from each library which were used for database construction. Organization of the database will permit observation of gene expression differences between the three growth states of A. cochlioides. The database is being integrated into the larger Oomycete Genomics Database at the National Center for Genome Research and is freely available to the research community. Inclusion of an Aphanomyces into this umbrella database that includes Saprolegnia and Phytophthora provides a valuable resource for comparative genomics.

Friesen, T. L., Weiland, J. J., Aasheim, M. L., Hunger, S., Borchard, D. C., Lewellen, R. T. 2005. Identification of a SCAR marker associated with Bm, the beet mosaic virus resistance gene, on chromosome 1 of sugar beet. Plant Breeding. 125:167-177.

Beet mosaic virus (BtMV) is an aphid transmitted, viral disease of beet found worldwide. The Bm gene, a resistance gene effective against BtMV, was identified in the sugar beet line 8500 and backcrossed into a C37 background to produce line C719. Three populations were developed from the cross of line C719 with the susceptible line C37 with the intent of developing markers for use in marker assisted selection. The F2 progeny of three crosses were scored for resistance. Two of the three populations conformed to a 3:1 ratio indicating a single gene trait. Sequence characterized amplified region (SCAR) markers were developed by using bulked segregant analysis (BSA) combined with random amplified polymorphic DNA (RAPD) type markers. The markers showed close

association to the Bm resistance gene and were effective in all three populations. This marker will be useful for the introgression of the Bm gene into germplasm. The A1 allele for genetic male sterility, assigned to chromosome 1, was found to be associated with Bm and the SCAR marker sequence used in this population was also used to develop a SNP marker in a second population to validate linkage to chromosome 1.

Weiland, J. J. Production of protease enzymes by Aphanomyces cochlioides and Aphanomyces euteiches. Physiological and Molecular Plant Pathology. 65:225-223.

The production of protease activity by the sugarbeet pathogen Aphanomyces cochlioides, the legume pathogen A. euteiches, and the fish pathogen Saprolegnia parasitica was examined. Protease activity was found to be readily detected in supernatants of water cultures of each organism using autoclaved host tissue as a nutrient source. Protease isozymes extracted from sugarbeet and pea seedlings infected with A. cochlioides and A. euteiches, respectively, co-migrated with enzymes produced by the pathogens in culture. Use of class-specific inhibitors indicated that a portion of the protease activity was of the trypsin-class. Trypsin-like isozymes that possessed a relatively fast electrophoretic migration were detected in the A. cochlioides, A. euteiches, and S. parasitica protease complements, whereas the remaining isozymes were not affected by any of the inhibitors tested. Proteinacious trypsin inhibitors from the legumes lima bean (Phaseolus lunatus) and soybean (Glycine max) were able to inhibit the trypsin-like isozymes from A. cochlioides, but not A. euteiches, whereas low molecular weight, synthetic trypsin inhibitors inhibited these isozymes from both pathogen sources. The potential role of protease inhibition in host range determination in the phytopathogenic Aphanomyces is discussed.

POLYMERASE CHAIN REACTION (PCR)-BASED DETECTION OF SUGARBEET FUNGAL PATHOGENS USING ACTIN AND rDNA GENE SEQUENCES

(Project 620)

John J. Weiland

The polymerase chain reaction (PCR) is a DNA based technique for amplifying specific sequences from the genomes of organisms. PCR technology has impacted many fields of biology, including the area of disease diagnosis in both plants and animals. Diagnostics using the PCR are sensitive and highly discriminatory, since they target genome regions whose DNA sequences have diverged throughout evolution. PCR-based diagnostics also require little time for a result to be secured (within one to two days), making them attractive to high-throughput diagnostic laboratories. More recently, exquisite quantitation of pathogens has been made a reality by the added technology of "real-time" PCR, a technology currently being used in our laboratory for the quantitation of gene expression and fungal genomes.

The interests in our laboratory include the development of novel diagnostic tools for disease-causing fungi in sugarbeet with a special emphasis on the highly destructive pathogen Aphanomyces cochlioides.. For this reason, we designed our PCR assay for the discrimination of sugarbeet fungal pathogens upon DNA sequences of the actin, ribosomal RNA (rRNA), and mitochondrial cytochrome b genes. The chosen genes harbor sequences that permit that organism to be "fingerprinted" according to that gene sequence. This fingerprinting analysis was applied to Aphanomyces populations that were collected in the U.S. ranging from the northern Red River Valley to (now abandoned) sugarbeet growing regions of Texas. The analysis revealed that Aphanomyces cochlioides populations in the central states of the U.S. are genetically uniform. Because of this, we sought to examine A. cochlioides isolates from a more localized region that nevertheless has some unique attributes.

Sugarbeet grown in the Southern Minnesota Beet Sugar Cooperative region is, in some cases, rotated with fields of green pea and with table beet. A. euteiches is a well known pathogen of peas in this area. In addition, it is known that A. cochlioides can infect table beet. We therefore collected soil samples from these regions in 2003 and have produced DNA preparations from 85 single-zoospore isolates from these samples. As a first step in developing PCR probes able to discriminate between A. cochlioides and A. euteiches, an alignment between the actin genes of these two pathogens was performed to identify sequences unique to each. The alignment revealed a position in the gene where two clustered nucleotide differences between the isolates were found (Fig. 1)

```
   *        380         *         400         *         420
AACAC2FR : CCATGTATGTGAACATCCAAGCCGTGTTGTCTTTGTACGCTTCTGGTCGTACCACTGGTT :  420
AACAC4FR : CCATGTATGTGAACATCCAAGCCGTGTTGTCTTTGTACGCTTCTGGTCGTACCACTGGTT :  420
AACAC5FR : CCATGTATGTGAACATCCAAGCCGTGTTGTCTTTGTACGCTTCTGGTCGTACCACTGGTT :  420
BACAC2FR : CCATGTATGTGAACATCCAAGCNGTGT-GTCTTTGTACGCTTCTGGTCGTACCACTG-TT :  416
BACAC3FR : CCATGTATGTGAACATCCAAGCCGTGTTGTCTTTGTACGCTTCTGGTCGTACCACTGGTT :  420
BACAC4FR : CCATGTATGTGAACATCCAAGCCGTGTTGTCTTTGTACGCTTCTGGTCGTACCACTGGTT :  420
AAEAC1FR : CCATGTACGTGAACATCCAAGCCGTGTTGTCTTTGTACGCTTCCGGCCGTACCACTGGTT :  420
AAEAC2FR : CCATGTACGTGAACATCCAAGCCGTGTTGTCTTTGTACGCTTCCGGCCGTACCACTGGTT :  420
AAEAC3FR : CCATGCACGTGAACATCCAAGCCGTGTTGTCTTTGTACGCTTCCGGCCGTACCACTGGTT :  420
AAEAC4FR : CCATGTACGTGAACATCCAAGCCGTGTTGTCTTTGTACGCTTCCGGCCGTACCACTGGTT :  420
BAEAC1FR : CCATGTACGTGAACATCCAAGCCGTGTTGTCTTTGTACGCTTCCGGCCGTACCACTGGTT :  420
BAEAC2FR : CCATGTACGTGAACATCCAAGCCGTGTTGTCTTTGTACGCTTCCGGCCGTACCACTGGTT :  420
BAEAC3FR : CCATGTACGTGAACATCCAAGCCGTGTTGTCTTTGTACGCTTCCGGCCGTACCACTGGTT :  420
BAEAC5FR : CCATGTACGTGAACATCCAAGCCGTGTTGTCTTTGTACGCTTCCGGCCGTACCACTGGTT :  420
           CCATGtA GTGAACATCCAAGCcGTGTtGTCTTTGTACGCTTC GG CGTACCACTGgTT
```

Figure 1. Subsequence of the actin genes of A. cochlioides and A. euteiches illustrating DNA polymorphism. The close proximity of the two boxed nucleotide substitutions enables PCR primers to be designed which discriminate between the two pathogens. Sequences shown are from A. cochlioides (xACxxxxx) and A. euteiches (xAExxxxx) isolates collected from fields in southern Minnesota.

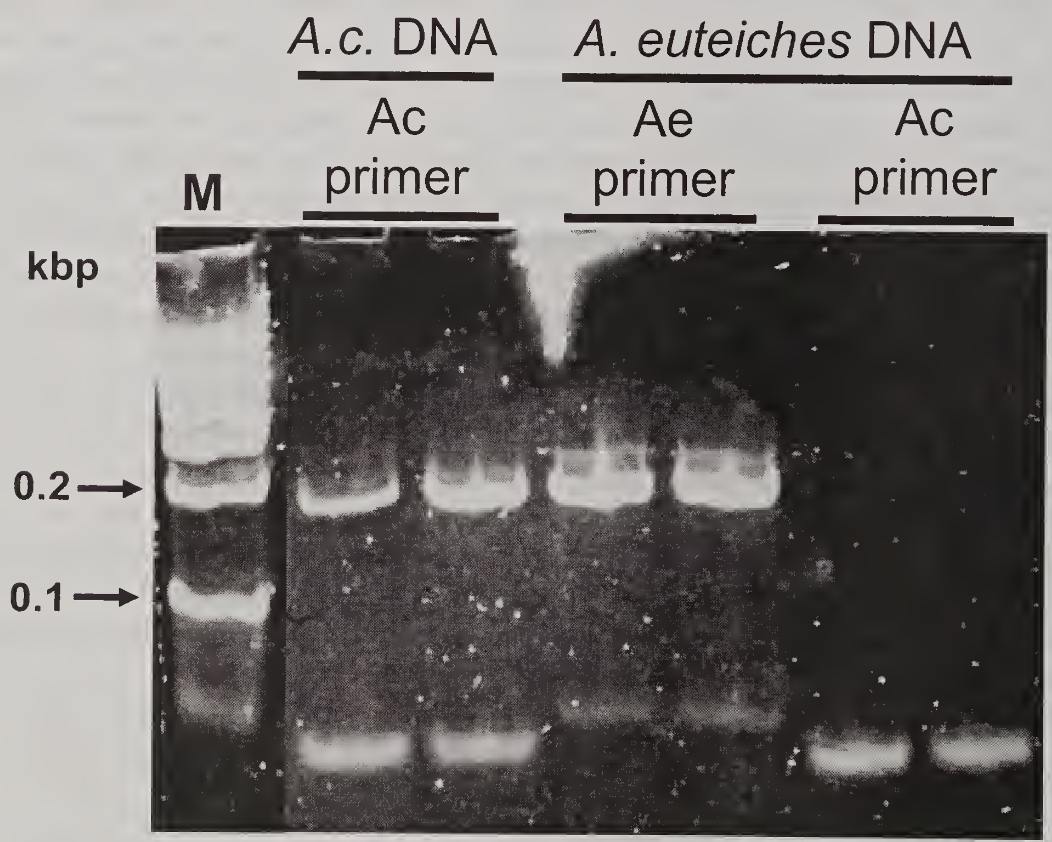

Figure 2. Specific detection of A. cochlioides by primers to actin gene sequences. PCR products were separated on a 5% polyacrylamide gel (Tris borate EDTA buffer) along with molecular weight standards (lane M). The Ac primers amplify a ~0.19 kilobasepair (kbp) product from A. cochlioides DNA, but not from A. euteiches DNA.

Primers designed to discriminate the two pathogens were used in PCR tests on purified DNA of A. cochlioides isolate 898B and A. euteiches isolate 19-1z. The primers designed to A. cochlioides detected this pathogen, but not A. euteiches, as predicted (Fig. 2). Since the primers were designed with the incorporation of fluorochromes possessing differing excitation and emission wavelengths, we are testing the use of a 96-well plate assay for the high-throughput detection of these pathogens without the use of electrophoresis.

In addition to genetic fingerprinting that can be performed with PCR technologies, real-time quantitative PCR (qPCR) can be used to quantitate levels of pathogen in infected tissue or in soils. Primer/probe combinations for qPCR detection of A. cochlioides were described in the 2004 Blue Book. The 2005 studies to be undertaken with qPCR analysis of A. cochlioides accumulation in sugarbeet genotypes possessing varying levels of resistance was interrupted by the discovery by our laboratory of the beet black scorch virus (BBSV)/Olpidium complex in the U.S. for the first time. Subsequent to the discovery, resources were applied to the development of detection methods for this virus and vector combination.

Purified BBSV obtained from infected Chenopodium quinoa (Fig. 3) was used to prepare antisera in rabbit. The antisera proved capable of detecting BBSV coat protein by Western blotting (Fig. 4). This antisera is being purified and the resulting IgG will be conjugated to alkaline phosphatase for use in a standard double antibody sandwich enzyme-linked immunosorbant assay (DAS-ELISA). These reagents will be made available for surveying the distribution of BBSV in the U.S.

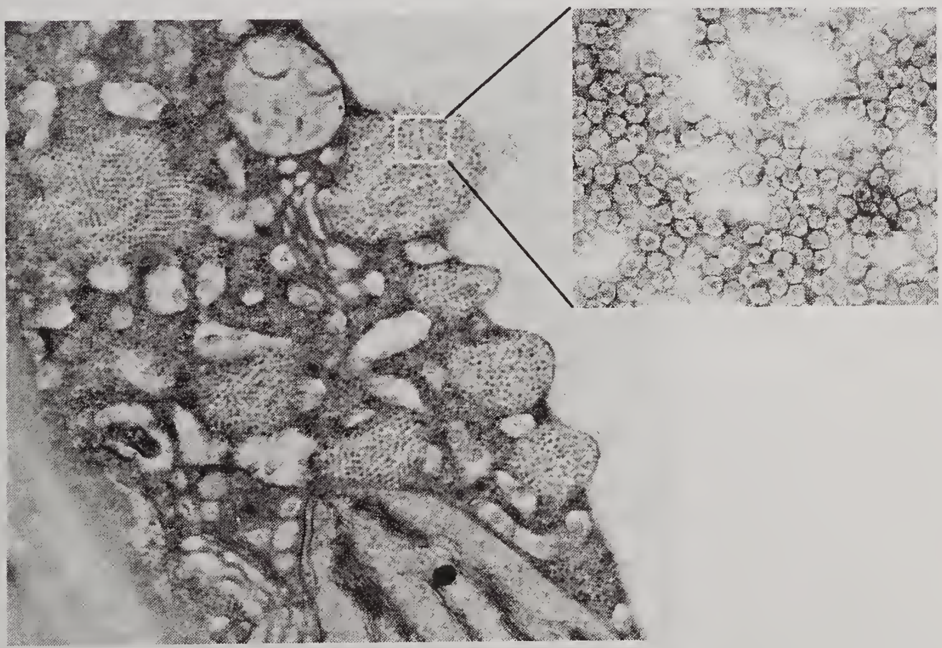

Figure 3. Beet black scorch virus particles in thin sections of C. quinoa. The virus is a small, spherical shape of ~29 nm diameter and belongs to the Necrovirus group. The leftward panel show the cell cytoplasm observed with transmission electron microscopy where pockets of virus particles are seen. The rightward panel shows a higher magnification illustrating particle morphology. [Photo courtesy of T. Freeman, North Dakota State University.]

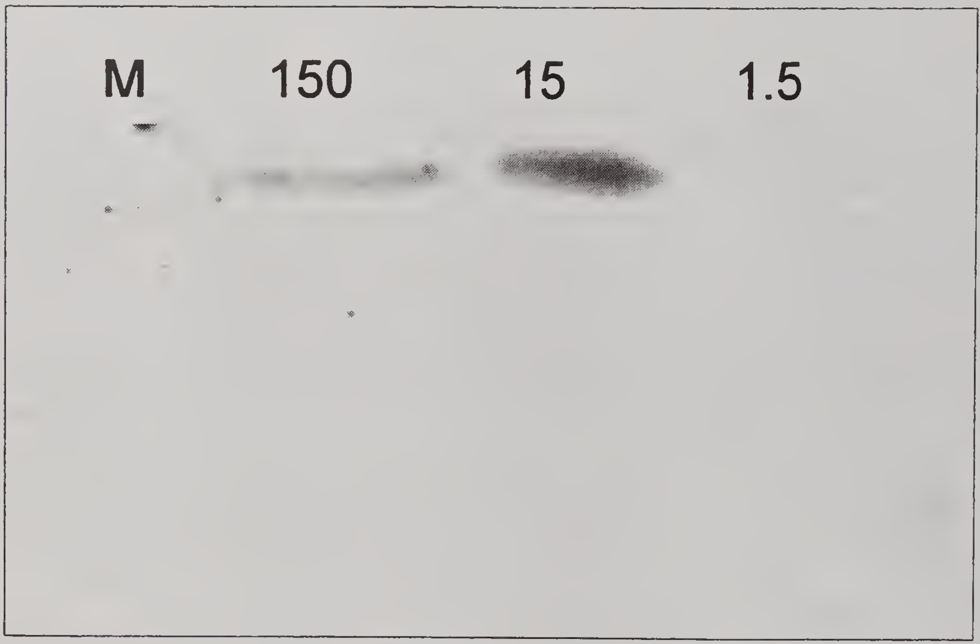

Figure 4. Western blot detection of BBSV coat protein using antisera prepared from rabbit in 2006. Dilutions of purified virus (150, 15 and 1.5 ng of virus as shown) were subjected to polyacrylamide gel electrophoresis under denaturing conditions and electroblotted to nitrocellulose. After reaction with a 1:1000 dilution of rabbit anti-BBSV antisera, the blot was treated with a peroxidase conjugate of goat anti-rabbit IgG. Addition of peroxidase substrate resulted in a chemiluminescent signal that was captured on X-ray film.

The vector for BBSV is reported to be Olpidium brassicae. Using publicly-available sequence of the internal transcribed spacer (ITS) region of the rDNA from O. brassicae, we have developed PCR primers for the detection of this organism and that of Polymyxa betae, the vector of Benyviruses of sugarbeet. In addition, a PCR primer set was developed for the detection of BBSV. Using these reagents, O. brassicae and BBSV (Figure 5) was detected in roots from which the original Colorado isolates of BBSV were found. O. brassicae further was detected in sugarbeet plants grown from seed that had been planted in soil from a Rhizomania research site east of Glyndon, Minnesota. To date, BBSV has not been detected in these samples, or elsewhere in the U.S. outside of the Colorado growing region.

With the availability of the antisera for ELISA and PCR primers for detection of BBSV and O. brassicae, we anticipate the initiation of a survey in 2006 for the evaluation of BBSV in sugarbeet production regions across the U.S. Additionally, inoculation tests of sugarbeet involving non-virulliferous O. brassicae combined with purified BBSV will be conducted in efforts to determine the impact of infection on beet yield and quality. Finally, the complete genome of BBSV has been cloned in our laboratory and is slated for sequencing in early 2006. This will permit comparison between the U.S. and Chinese isolates of BBSV, enabling a glimpse into potential genome differences, which may result in virulence differences between the two strains.

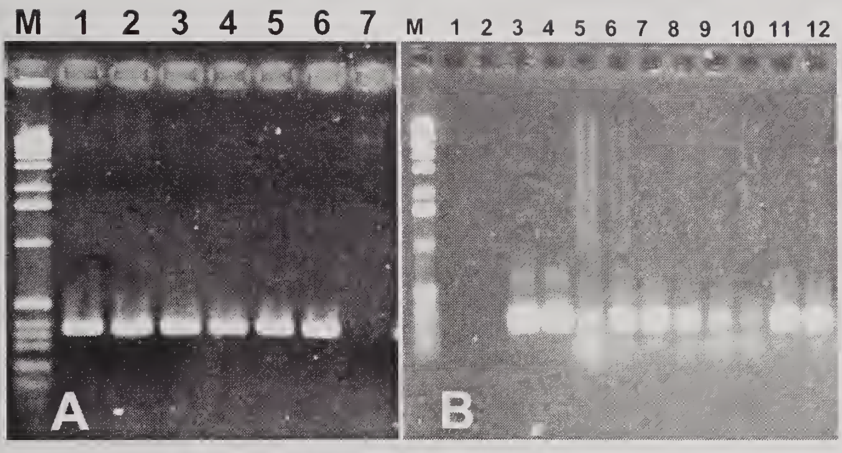

Figure 5. Detection of BBSV in sugarbeet root samples from Colorado (Panel A) and of Olpidium brassicae in beet seedlings grown in soil from Minnesota (Panel B). Agarose gel electrophoresis was used to separate PCR products resulting from the amplification. Lanes 7 of panel A and 1 and 2 of panel B are negative controls. Samples were analyzed in duplicate and a subset of the products shown were cloned and sequenced to confirm the sequence for the target organism.

MECHANISMS OF RESISTANCE IN SUGARBEET TO FUNGAL AND BACTERIAL PATHOGENS

(Project 621)

John J. Weiland

Enzymes and enzyme inhibitors that accumulate in sugarbeet that is under pathogen stress often are associated with resisting pathogen invasion. Some of these activities are produced to strengthen natural barriers in the plant to pathogen invasion. Others are produces as an arsenal of compounds toxic to the pathogen or as inhibitors of phytotoxins produced by the pathogen. Identification of sugarbeet enzymes, and their corresponding genes, produced in defense against pathogens can further our understanding of the basis for disease resistance. Such knowledge can be used in the selection of germplasm with enhanced pathogen resistance. In addition, the cloning of the genes for defense-related enzymes and inhibitors can lead toward the production of genetically modified (engineered) germplasm for use in sugarbeet breeding programs.

Protease activity secreted in to the culture media by A. cochlioides is being investigated as a virulence component in the production of disease in sugarbeet. Proteases are produced in abundance by Aphanomyces species, including those that infect fish and crayfish. Previously in our lab, it was shown that a proteinase inhibitor from lima bean effectively inhibits a subset of the proteases that are separable using gel electrophoresis. In 2004, we began purifying a ~70 kilo Dalton protease expressed by A. cochlioides that is abundantly produced in infected sugarbeet seedlings and antiserum production was initiated against this protein. Unfortunately, the purification scheme was unable to yield pure enough protein for such an application. Thus, the resulting antisera will need to be fractionated for IgG purification by affinity chromatography, to enrich for the IgG class specific for the target protease.

During this period, a project to sequence expressed sequence tags (ESTs) of A. cochlioides also was completed in 2005 and the results posted on-line (Fig. 1 and see website http://www.oomycete.org/ogd/filter.html). This data can be used to analyze (1) genes of A. cochlioides expressed in culture versus in infected sugarbeet seedlings and (2) genes of sugarbeet seedlings expressed upon attack by A. cochlioides. Preliminary investigation with the database confirms the presence of protease genes from A. cochlioides that are expressed in culture and in infected plants. Additional novel genes expressed in infected sugarbeet seedlings include those encoding proteinase inhibitors, polygalacturonase, and (from the sugarbeet host) polygalacturonase inhibitor protein. The database will prove useful for unraveling the molecular basis for the infection of sugarbeet by this serious disease pathogen.

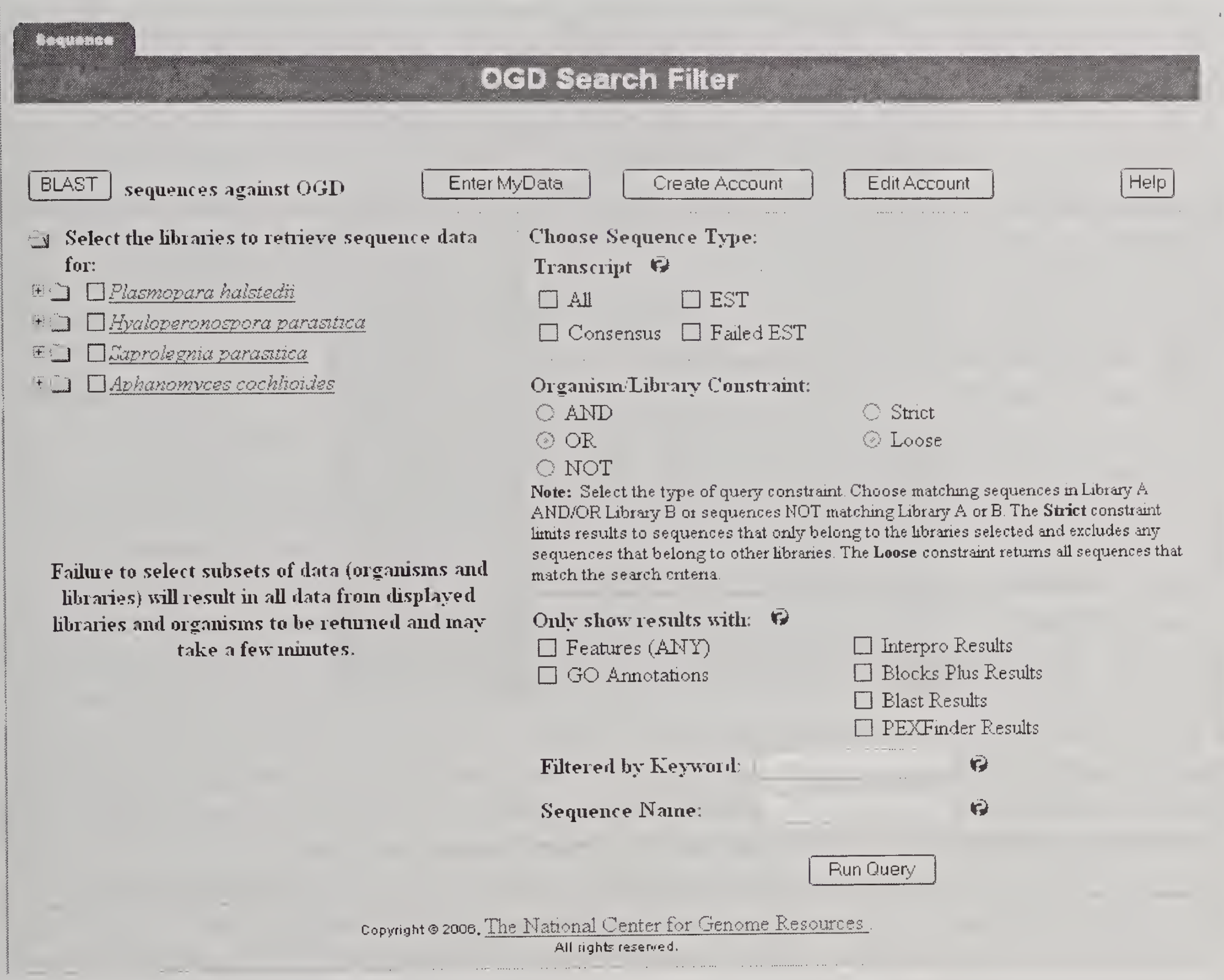

Figure 1. Entry web page for the A. coehlioides EST database. The data are housed at the National Center for Genome Resourees (Santa Fe, NM) and are incorporated under the umbrella Oomyeete Genomies Database organized by Sophien Kamoun (Ohio State University, Wooster).

This document represents the close-out of Project 621. With the placement of the USDA-ARS Sugarbeet research program in the proteomics of disease and resistance at Fort Collins, CO, combined with the rise of new disease problems in the sugarbeet crop in the northern Plains, priority in sugarbeet pathology at Fargo is being given to emerging disease identification and diagnosis as well as the continued tagging of genes in sugarbeet conferring resistance to pathogens and pests.

TAGGING OF GENES FOR DISEASE RESISTANCE IN SUGARBEET USING MOLECULAR GENETIC MARKERS

(Project 622)

John J. Weiland

Markers that tag regions of chromosomes that harbor genes contributing to disease resistance in sugarbeet can be of use in many aspects of research. Such landmarks on the genomic map can be used in marker-assisted selection in sugarbeet breeding programs. In addition the markers can provide information regarding the clustering or lack thereof regarding the distribution of resistance genes throughout the genome. Finally, chromosome markers can be integral tools in the identification of DNA clones that potentially harbor resistance gene sequences. Cloned resistance genes can be analyzed for clues as to their mode of action and can be transferred between plant species using gene transfer technologies.

We have focused early efforts on the tagging of resistance to powdery mildew disease and to root knot nematode. Similar work has already been done in European laboratories the analysis of resistance to Cercospora leaf spot and Rhizomania diseases. Powdery mildew (Erysiphe polygoni) and root knot nematode (Meloidogyne spp) resistance in sugarbeet has recently been characterized by ARS colleagues in Salinas, CA. Both genes show promise for the genetic control of several races of the organisms causing these diseases. In collaboration with Drs. Robert Lewellen (ARS-Salinas) and J. Mitch McGrath (ARS-East Lansing), these resistance genes are being tagged using the random amplified polymorphism (RAPD) technique. An additional project in which the Bm gene for resistance to beet mosaic virus (BtMN) was tagged recently is being published in Plant Breeding in 2006.

In efforts to produce more robust markers for the Pm gene conferring resistance to powdery mildew disease, advanced populations provided by Dr. Lewellen were screened in the greenhouse at Fargo in 2004. Sugarbeet populations CP04 and CP06 were the focus of gene tagging efforts following the preparation of DNA. Markers developed from these populations have, to date, been problematic for cloning. In addition to standard RAPD approaches, we have included novel primers in the process, including that of the transposable element Vulmar which is widely distributed in the sugarbeet genome (Jacobs et al., Genome, v47:1192-1201, 2004). In collaboration with Anne Gillen (USDA-ARS, Kimberly ID) we are exploring the use of single nucleotide polymorphism (SNP) markers for linkage in our DNA samples to the trait of Pm–derived resistance. This will target Beta vulgaris linkage group 2 which has been reported to encode this gene. In addition, some of the potential markers segregating in repulsion with Pm (Fig. 1) will be re-investigated for use in tagging this gene.

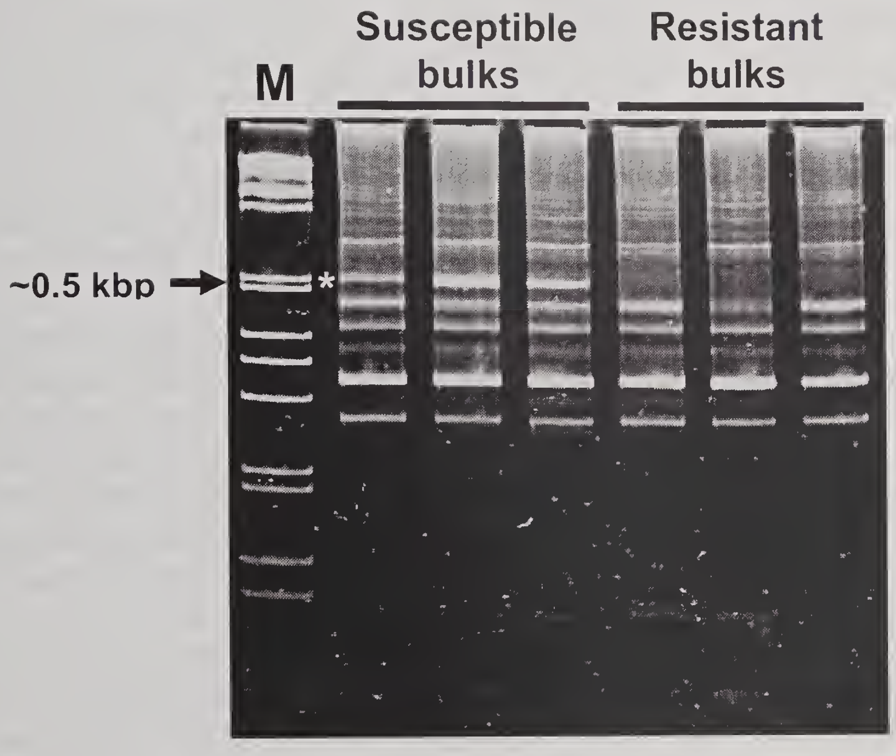

Figure 1. RAPD analysis applied to bulked DNA from population CP04 segregating for resistance to powdery mildew disease in sugarbeet. Amplified products were separated on a 5% polyacrylamide gel and photographed after staining with ethidium bromide. The white asterisk indicates a product amplified from the DNA of susceptible plants and not in that from resistant plants.

Finally, studies on the segregation of resistance to Aphanomyces and sugarbeet cyst nematode (SBCN) will be done using populations generated by Drs. Bob Lewellen at USDA-ARS in Salinas, CA and Lee Panella at the USDA-ARS in Fort Collins, CO. Source materials from B. vulgaris spp maritima have yielded segregating populations with improved resistance to SBCN as assayed in California soils and under artificial inoculation. Discussions with Drs. Lewellen and Panella indicate that DNA should be able to be prepared by early 2006. Tagging of the gene(s) for resistance to this pest will commence shortly thereafter.

ROLE OF SUCROSE METABOLIZING ENZYMES IN SUGARBEET GROWTH, CARBOHYDRTE PARTITIONING AND POSTHARVEST SUCROSE LOSS

(Project 650)

Karen L. Klotz

Sucrose catabolism has been implicated as a major factor controlling whole plant carbon partitioning, root growth, sucrose accumulation, and postharvest sucrose loss (Wyse, 1974; Giaquinta, 1979; Sung et al., 1989; Zrenner et al., 1995; Berghall et al., 1997). In sugarbeet root, sucrose catabolism is catalyzed by three enzyme activities: sucrose synthase, acid invertase and alkaline invertase. Although all three activities are found in sugarbeet root, sucrose synthase is the predominant activity during root development and accounts for more than 90% of the total soluble sucrolytic activity during postharvest storage (Klotz and Finger, 2002; 2004). The enzyme is involved in sucrose utilization during development (Xu et al., 1989; Amor et al., 1995), has been implicated in sucrose partitioning to storage organs (Sung et al., 1989; Zrenner et al., 1995) and is believed to be the enzyme largely responsible for postharvest sucrose degradation in sugarbeet (Echeverría and Gonzalez, 2003).

Two sucrose synthase genes have been identified in sugarbeet, sugarbeet sucrose synthase 1 (SBSS1; Hesse and Willmitzer, 1996) and sugarbeet sucrose synthase 2 (SBSS2; Haagenson et al., 2006). Previous research has demonstrated that both genes are highly expressed in roots, developmentally regulated, and relatively unresponsive to typical postharvest stresses including harvest, wounding, cold temperature, and anaerobic conditions (Haagenson et al., 2006; Klotz and Haagenson, submitted). In the course of these studies, transcriptional changes were observed that suggested sucrose synthase gene expression was regulated diurnally and by shoot-derived signals. In research conducted during the past year, the possible regulation of sucrose synthase expression by diurnal or shoot-derived signals was determined. Research was also initiated to determine the tissue-specificity of sucrose synthase gene expression, since this may give clues to the individual function of sucrose synthase genes, and to construct plasmids that will be used to alter sucrose synthase gene expression in planta. The generation of plants with altered sucrose synthase expression will provide the means to directly probe the function of individual sucrose synthase genes and determine their influence on root yield, sucrose content and postharvest loss. Research examining the regulation of sucrose synthase expression by diurnal and shoot-derived signals is presented in this report. Research conducted towards localizing sucrose synthase expression and altering in planta levels of sucrose synthase, however, is not discussed since these projects are in their initial stages and have yet to yield results.

Research was also initiated during the past year to develop a high-throughput, enzyme-based assay to quantify sucrose and the common carbohydrate impurities present in sugarbeet roots. A microtiter plate assay for quantification of sucrose, glucose, fructose and raffinose has been developed, but still needs minor refinement and has yet to be validated using sugarbeet extracts quantified by both HPLC and the newly developed assay. If the assay proves to be accurate, it will provide a rapid and cost-efficient method to quantify carbohydrates, and may prove useful for screening germplasm for sucrose and carbohydrate impurity content and for monitoring carbohydrate changes during postharvest storage.

Potential Regulation of Sucrose Synthase Gene Expression by Diurnal and Shoot-Derived Signals

In previous research, sucrose synthase gene transcript levels transiently declined during the day and in gently harvested roots, possibly due to diurnal regulation and the loss of shoot-derived signals, respectively. { SEQ CHAPTER \h \r 1}To investigate whether the transcript changes observed in these previous studies were due to diurnal regulation and shoot-derived signals, SBSS1 and SBSS2 RNA abundances were determined in roots of intact and decapitated plants at 6 h intervals over 2 d (Fig. 1). The experiment was conducted with 16-wk old plants that were maintained in a greenhouse under a 16 h light/8 h dark regime before and throughout the experiment, with sampling initiated at the beginning of a light period. Since differences in SBSS1 and SBSS2 transcript abundances in relation to time of day and decapitation were difficult to interpret due to unequal loading of RNA (Fig. 1a), SBSS1 and SBSS2 signal intensities were normalized using the signal intensity of the 18S ribosomal RNA for each lane (Fig. 1b).

SBSS1 and SBSS2 transcript levels in roots of intact plants varied over the course of two day/night cycles, although no consistent diurnal pattern was observed for either gene (Fig 1, control). Removal of the shoot caused a marked reduction in SBSS1 transcript levels suggesting that shoot-derived signals increase SBSS1 expression. SBSS1 transcript levels were 40% lower in roots 6 h after decapitation and declined another 30% from transcript levels at time of decapitation during the following 42 h. In contrast, the influence of shoot-derived signals on SBSS2 expression varied with time after decapitation. SBSS2 levels in decapitated roots, relative to levels in intact plants, were higher 6 and 12 h after shoot removal and lower 18 to 48 h after shoot removal. The identity of shoot-derived signals that may influence sucrose synthase expression is presently unknown. Although sucrose is a regulator of sucrose synthase.

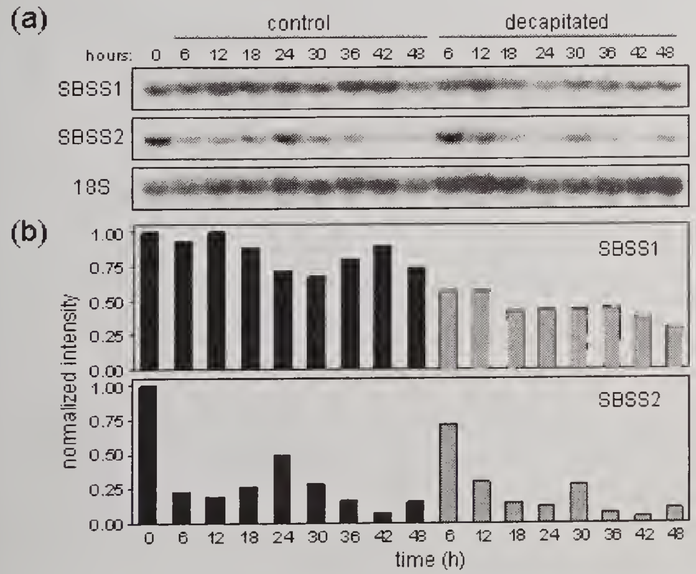

Figure 1. Diurnal changes and the effect of decapitation on sugarbeet sucrose synthase (SBSS1) and sugarbeet sucrose synthase 2 (SBSS2) RNA abundance. (a) Northern analyses with 10 µg total RNA per lane hybridized to ^{32}P-labeled SBSS1, SBSS2, and 18S ribosome DNA probes. (b) Normalized SBSS1 and SBSS2 signal intensity obtained by division of SBSS1 or SBSS2 signal intensity for each lane by the lane's respective 18S ribosomal RNA signal intensity. The normalized signal intensity for

root samples at 0 h was arbitrarily set to 1.00 transcription in other plant species and is supplied from the shoot, it is unlikely to be the signal responsible for altered sucrose synthase expression in sugarbeet root. SBSS1 transcript levels have previously been shown to be unaffected by sucrose, glucose or fructose (Hesse and Willmitzer, 1996) and it is unlikely that shoot removal would lead to sucrose depletion in a sugarbeet root.

Development of an Enzyme-Based Microtiter Plate Assay for Sucrose, Glucose, Fructose and Raffinose

Since currently used methods of carbohydrate quantification are inaccurate for the analysis of deteriorated roots (polarimetry, refractometry), costly (HPLC), and/or time-consuming (HPLC, GC), research was initiated to develop a rapid and cost-efficient method for quantifying sucrose and common carbohydrate impurities in sugarbeet samples. Previously, an enzyme-based microtiter plate assay was described for the analysis of sucrose, glucose and fructose (Spackman and Cobb, 2001). Although the assay accurately quantified sucrose and typical carbohydrate impurities found in sugarbeet roots, its time-consuming sample preparation steps, long assay times, and narrow linear range limited its usefulness. Research was initiated to modify this assay to rectify its limitations and expand it to quantify raffinose in addition to sucrose, glucose, and fructose.

The assays use sucrose, glucose, fructose and raffinose as substrates for a series of enzyme catalyzed reactions to form products whose concentrations can be easily determined spectrophotometrically using a microtiter plate reader (Figure 2). Assays for sucrose, glucose and fructose determinations use a commercially available diagnostic reagent that couples glucose to the reduction of NAD^+ using the enzymes hexokinase and glucose 6-phosphate dehydrogenase. In these assays, the concentration of NADH produced is indicative of the initial concentration of carbohydrate. For determination of glucose concentration, the reagent is used without modification (Figure 2, equation 1). For determination of fructose concentration, phosphoglucose isomerase is added to the reagent allowing NAD^+ to be reduced by fructose as

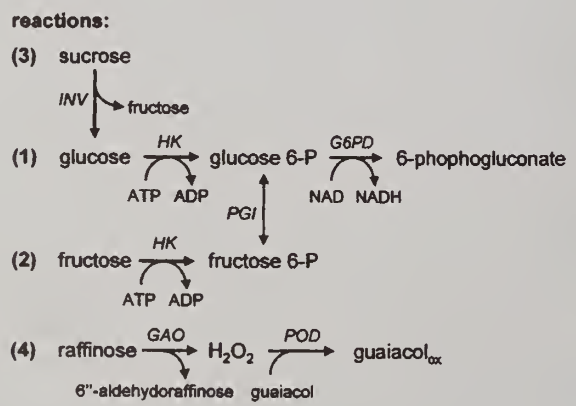

Figure 2. Enzyme catalyzed reactions used to determine sucrose, glucose, fructose and raffinose concentrations. Assays for sucrose, glucose and fructose measure NADH formation at 340 nm; raffinose assay measures the formation of oxidized guaiacol (biphenoquinone) at 470 nm. Enzyme abbreviations: G6PD, glucose 6-phosphate dehydrogenase; GAO, galactose oxidase; HK, hexokinase; INV, invertase; PGI, phosphoglucose isomerase; POD, peroxidase as well as glucose (Figure 2,

equation 2). For determination of sucrose concentration, sucrose is first cleaved to glucose and fructose by the enzyme, invertase (Figure 2, equation 3), and the glucose formed by this reaction is determined. For determination of raffinose concentration, a new assay was developed which utilizes galactose oxidase and peroxidase to couple the oxidation of raffinose to the oxidation of guaiacol (Figure 2, equation 4). In this assay, the concentration of biphenoquinone, the oxidized form of guaiacol, is indicative of the initial raffinose concentration.

Since four separate reaction sequences are needed to determine sucrose, glucose, fructose and raffinose concentrations, analysis of each root sample requires four wells of a 96-well microtiter plate. Allowing for wells to be used to generate standard curves, concentrations of the four carbohydrates can be determined simultaneously in 20 samples. Time required for complete reaction is 15 minutes. Complete details of the assay are provided below.

Carbohydrate standards were used to determine the linear range of the assays. Assays were linear for sucrose between 5 and 200 mg L^{-1}, for glucose and fructose between 2 and 100 mg L^{-1} and for raffinose from 5 to at least 300 mg L^{-1} (Figure 3). Initial research suggests that aluminum sulfate at concentrations typically found in brei samples does not interfere with the assays.

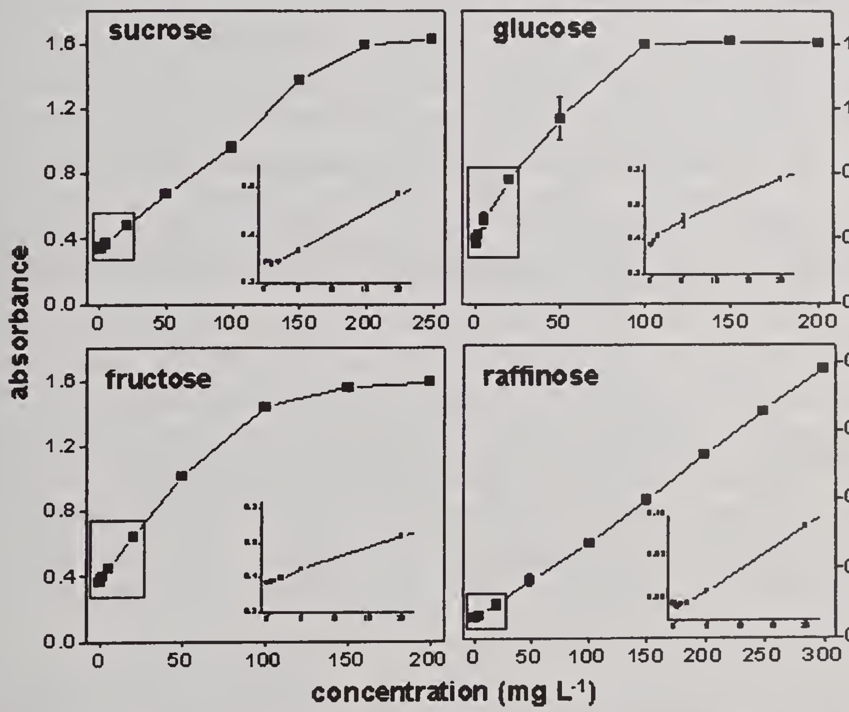

Figure 3. Absorbance as a function of carbohydrate concentration for sucrose, glucose, fructose and raffinose using the developed assay. Insets magnify the boxed region of the curve between 0 and 20 mg L^{-1} carbohydrate. Each data point is the average of 5 replicates. Absorbance for sucrose, glucose and fructose was determined at 340 nm. Absorbance for raffinose was determined at 425 nm. Error bars are ± the standard error where this exceeds the size of the symbol.

<u>Assay Description</u>. Glucose UV Liquid Plus Reagent was purchased from RaiChem Clinical Chemistry Reagents, San Diego, CA and contained 1500 U L^{-1} hexokinase (EC 2.7.1.1), 1000 U L^{-1} glucose-6-phosphate dehydrogenase (EC 1.1.1.49), 0.8 mM ATP, and 2 mM NAD in a pH 7.6 buffered solution. To this reagent, an additional 0.8 mM ATP and 0.8

mM $MgCl_2$ was added to form Glucose Reagent (GlcRgt). Yeast invertase (EC 3.2.1.26, saccharase, 334 U mg^{-1}) was purchased from Calbiochem, San Diego, CA and was prepared as a 17,500 U L^{-1} solution in 30 mM NaOAc, pH 4.6 (Invertase sol'n). Phosphoglucose isomerase (EC 5.3.1.9, 350 U mg^{-1}) was purchased from Roche Diagnostics Corp., Indianapolis, IN, and was added to GlcRgt at a concentration of 1470 U L^{-1} to form Invert Reagent (InvRgt). Galactose oxidase (EC 1.1.3.9, 82 U mg^{-1}) from Dactylium dendroides and peroxidase (EC 1.11.1.7, 217 U mg^{-1}) from horseradish root were purchased from Worthington Biochemical Corp., Freehold, NJ, and were dissolved in 50 mM potassium phosphate buffer pH 7.0 at concentrations of 2700 U L^{-1} and 7200 U L^{-1}, respectively. Guaiacol was purchased from Cayman Chemical, Ann Arbor, MI, and prepared as a 0.24 M stock solution in ethanol. Raffinose reagent (RafRgt) was prepared daily by the addition of 2.4 mM guaiacol to the buffered solution containing galactose oxidase and peroxidase.

Assays were conducted in Falcon flat-bottom 96 well plates (Fisher Scientific, Pittsburgh, PA) in a total volume of 200 µL. A Molecular Devices SpectraMax Plus microplate spectrophotometer (Sunnyvale, CA) was used to homogenize assay solutions, incubate reactions and determine absorbance. Four wells were required to determine glucose, fructose, sucrose and raffinose concentrations per sample. Colorimetric reactions were carried out in these four wells to determine (1) glucose concentration, (2) the combined concentration of glucose and fructose, (3) the combined concentration of sucrose and glucose, and (4) raffinose concentration. Carbohydrate concentrations were determined by comparison of absorbances to standard curves, and the concentrations of fructose and sucrose were determined by subtraction of glucose concentration (well 1) from the values obtained for the combined concentration of glucose and fructose (well 2) and the combined concentration of sucrose and glucose (well 3). Reactions to determine glucose, combined glucose and fructose concentrations, and raffinose concentration used 10 µL of root extract or carbohydrate standard with 190 µL GlcRgt, InvRgt, and RafRgt, respectively. To determine the combined concentrations of glucose and sucrose, 10 µL of root extract or sucrose standard was initially incubated with 90 µL of invertase sol'n for 10 min at 25°C, and 10 µL of this solution was reacted with 190 µL GlcRgt. All assay mixtures were agitated for 60 s, and incubated at 25°C prior to determination of absorbance. Reactions were incubated for 15 min except when testing the rapidity of reactions when absorbance was determined after incubation for 5, 10, 15, 20 and 25 min. Absorbance was determined at 340 nm for reactions containing GlcRgt and InvRgt, and at 470 nm for reactions containing RafRgt.

CONCLUSIONS:

- Sucrose synthase genes do not exhibit diurnal regulation of expression as previously suspected.

- Expression of sugarbeet sucrose synthase 1 (SBSS1) is positively affected by signals originating in the shoot, although the identity of the compound(s) is unknown.

- A microtiter plate assay is under development that may allow for the rapid quantification of sucrose, glucose, fructose and raffinose. Optimization of the method is nearly complete. The method has not been validated by comparing its accuracy to HPLC using a large number of root samples of varying quality.

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CHARACTERIZATION OF RAFFINOSE BIOSYNTHESIS DURING SUGARBEET GROWTH AND STORAGE

(Project 651)

Karen L. Klotz

Raffinose is a carbohydrate impurity that decreases the yield of extractable sucrose and alters sucrose crystal morphology reducing filtration rates and slowing processing. Raffinose concentrations may increase with prolonged periods of cold (less than 3°C) during sugarbeet growth and storage. Although increased raffinose concentrations have been observed during cold storage, the physiological and biochemical mechanisms associated with raffinose accumulation in sugarbeet are poorly understood. Raffinose synthesis is catalyzed by raffinose synthase, an enzyme that transfers a galactosyl unit from galactinol to sucrose. The formation of galactinol is the first committed step in the synthesis of raffinose and this reaction is catalyzed by galactinol synthase. The objective of this research was to evaluate sugarbeet raffinose accumulation and raffinose biosynthetic enzyme activity during sugarbeet storage in an attempt to identify the physiological, biochemical, and environmental factors associated with sugarbeet raffinose accumulation. This report summarizes the second year of a two-year field study in which field-grown roots were harvested from a Fargo, ND location at three dates (7 September, 27 September, and 26 October 2004), and were stored for 2, 10, and 18 wk at 2 or 6°C, respectively. Root tissues were analyzed for raffinose content, and galactinol synthase and raffinose synthase enzyme activities.

Impact of Harvest Date, Storage Duration and Storage Temperature on Raffinose Concentrations

Harvest date, storage duration, and storage temperature had a significant impact on raffinose concentrations (Figure 1). Delaying the harvest date increased raffinose concentrations at harvest. At harvest, raffinose concentrations were lowest from roots harvested 7 Sept., highest from roots harvested 26 Oct., and intermediate in roots harvested 23 Sept. During storage, raffinose concentrations from roots harvested 7 Sept. and 27 Sept increased during storage, but concentrations from roots harvested 26 October decreased after 18 weeks in storage. At 18 wk of storage, root raffinose concentrations were highest from sugarbeet harvested 7 Sept., lowest from sugarbeet harvested 26 Oct., and intermediate from roots harvested 23 Sept. Storage temperature had a significant impact on raffinose concentrations at 10 wk of storage as roots stored at 2ºC had 38% higher raffinose concentration than roots stored at 6ºC.

Influence of Harvest Date, Storage Duration and Storage Temperature on Galactinol Synthase and Raffinose Synthase Enzyme Activity

<u>Galactinol Synthase Activity:</u>

Root galactinol synthase activity was influenced by harvest date, storage duration, and storage temperature (Figure 2A). Delaying the harvest date significantly increased initial galactinol synthase enzyme activity. Galactinol synthase enzyme activity from roots

harvested 26 Oct. was 20-fold greater than that from the 7 Sept. harvest and was 36% greater than activity at the 27 Sept. harvest. Storage duration had a significant impact on enzyme activity. Galactinol synthase activity was highest at 2 wk of storage, decreased 16-fold at 10 wk, and remained low at 18 wk. Roots stored for 2 wk at 2°C had approximately 2-fold higher galactinol synthase enzyme activity when compared to roots stored at 6°C.

Raffinose Synthase Activity:

Harvest date influenced raffinose synthase activity as initial enzyme activity was greater in roots harvested 7 Sept. than those harvested 27 Sept. or 26 Oct., and roots harvested 26 Oct. generally had lower enzyme activity than those harvested in Sept. regardless of storage temperature or duration (Figure 2B). For all harvest dates, enzyme activity increased after 2 weeks storage at both 2 and 6°C, although the increase was significantly greater at 2°C. After 18 wk storage, raffinose synthase activity generally decreased at both storage temperatures. Enzyme activity was lower in roots stored at 6°C than in roots stored at 2°C for 2 and 10 weeks, but was similar for both storage temperatures at 18 weeks.

SUMMARY:

- Roots harvested in early September had the lowest raffinose concentration at harvest, but had the highest raffinose concentration after 18 wk in storage. Delayed root harvest was associated with increased raffinose concentration at harvest, but the lowest raffinose concentrations after 10 and 18 wk of storage.

- Galactinol synthase enzyme activity increased with later harvest and after 2 wk of storage, but declined significantly after 10 wk in storage. After 2 wk in storage, galactinol synthase enzyme activity was 2-fold higher from roots stored at 2°C than in roots stored at 6°C.

- Early harvested roots had increased raffinose synthase enzyme activities at harvest and during storage when compared to activity from roots harvested 26 Oct. Decreased storage temperature (2°C) was generally associated with increased raffinose synthase enzyme activity after 2 and 10 weeks in storage, but not at 18 weeks.

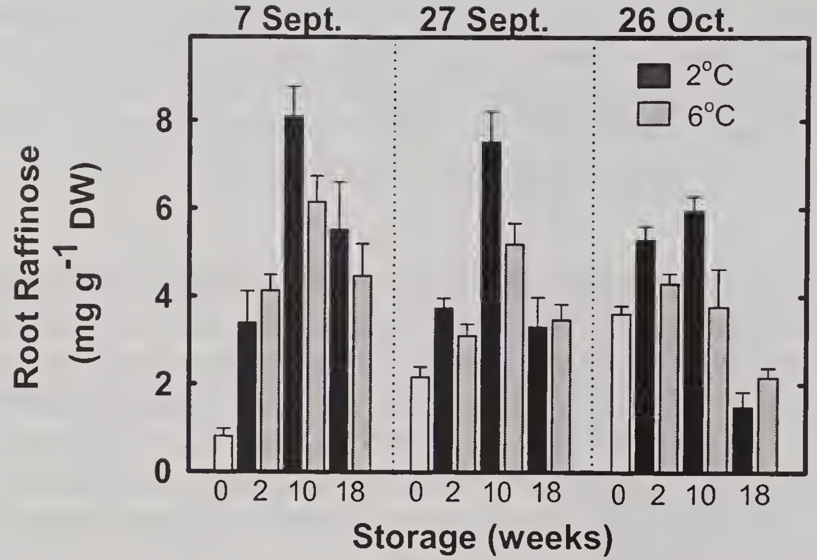

Figure 1. Impact of harvest date, storage temperature and duration on root raffinose concentration. Data are the mean ± SE of 4 replicates (10 roots/replicate).

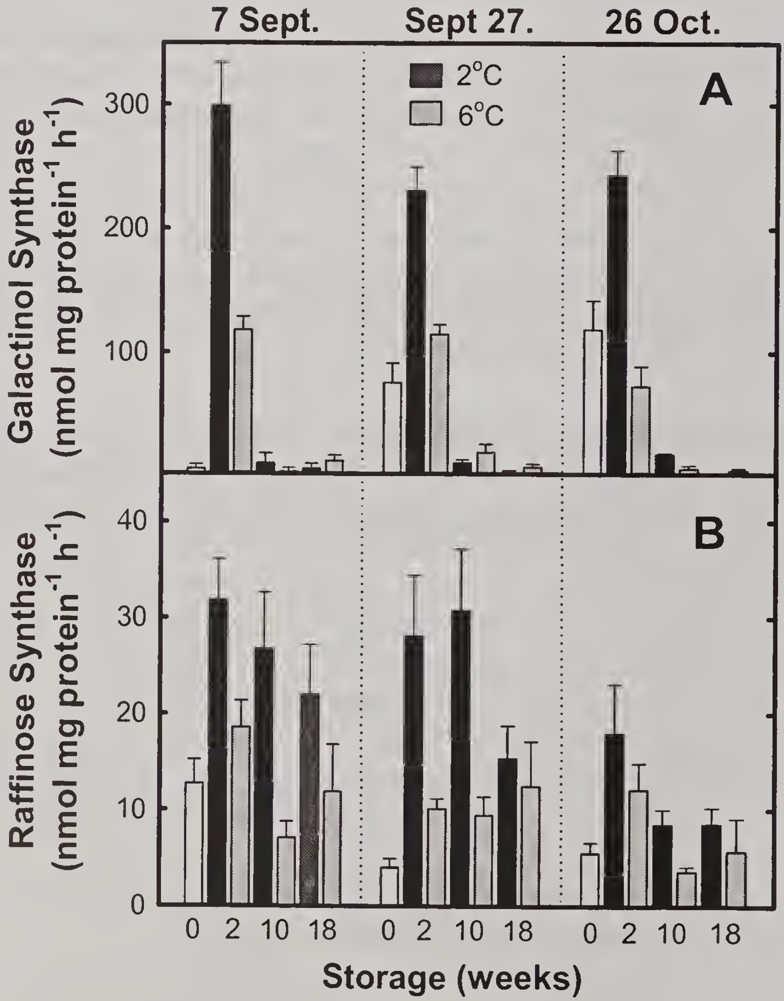

Figure 2. Impact of harvest date, storage temperature and duration on root galactinol synthase (A) and raffinose synthase (B) enzyme activity. Data are the mean ± SE of 4 replicates (10 roots/replicate).

SUGARBEET RESEARCH
USDA-ARS SUGARBEET AND BEAN RESEARCH UNIT
EAST LANSING, MICHIGAN

2005 REPORT

SECTION D

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This research was supported in part by funds provided through the Beet Sugar Development Foundation. (Project 744)

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INTRODUCTION

The Sugarbeet and Bean Research Unit at East Lansing, Michigan has projects involved with sugarbeet, dry bean, apple, and cucumber. Currently, a sugarbeet geneticist and an agricultural engineer are active. Two positions are open, a sugarbeet pathologist and a dry bean geneticist, and these will be recruited in the coming months. The sugarbeet program has three primary areas of investigation. First is breeding enhanced germplasm for adaptation to the Eastern US growing areas, with a priority on high sucrose, smooth root, and seedling disease resistance. Second is determining genetics of agronomic traits including sucrose accumulation, inheritance of seedling disease resistance, developing recombinant inbred lines, and constructing and characterizing molecular tools for the community (genetic maps, expressed sequence tags, bacterial artificial chromosome libraries). Third is the investigation of seedling vigor, including field emergence and stand establishment, stand persistence, development of *in vitro* germination and vigor tests, and molecular characterization of early plant development.

PUBLICATIONS IN 2005:

Dale, T.M, McGrath, J.M., Renner, K.A. (2005) Response of sugarbeet (*Beta vulgaris*) varieties and populations to postemergence herbicides. *J. Sugarbeet Research* 119-126.

Dong, F., Tek, A.L., Frasca, A.B.L., McGrath, J.M., Wielgus, S.M., Helgeson, J.P., Jiming J. (2005) Development and characterization of potato-*Solanum brevidens* chromosomal addition/substitution lines. *Cytogenetic and Genome Research* 109: 368-372.

McGrath, J.M., Biancardi, E. (2005) Sugar content, root weight, and sugar yield. In: Biancardi, E., Campbell, L., Skaracis, G.N., de Biaggi, M. (eds) Genetics and Breeding of Sugarbeet. Science Publishers, Inc., New Hampshire, USA. Pp. 119-122.

McGrath, J.M. (2005) Genomics in Genetic Improvement. In: Biancardi, E., Campbell, L., Skaracis, G.N., de Biaggi, M. (eds) Genetics and Breeding of Sugarbeet. Science Publishers, Inc., New Hampshire, USA. Pp. 221-234.

McGrath, J.M. (2005) Deployment of Beta genetic resources. In Report of a Working Group on Beta and World Beta Network. Second joint meeting, 23-26 October 2002, Bologna, Italy (L. Frese, C. Germeier, E. Lipman, and L. Maggioni, compilers). International Plant Genetic Resources Institute, Rome, Italy. Pp. 108-110.

Trebbi D (2005) Genetic analysis of sucrose accumulation in sugar beet (*Beta vulgaris* L.). Dissertation for Doctor of Philosophy, Michigan State University, East Lansing.

SUGAR BEET ACTIVITIES THE USDA-ARS EAST LANSING CONDUCTED IN COOPERATION WITH SAGINAW VALLEY BEAN AND BEET FARM DURING 2005

J. Mitchell McGrath, Tim M. Duckert, Teresa Koppin and Scott Shaw
USDA – Agricultural Research Service, East Lansing, Michigan

Six evaluation plots were planted at the Saginaw Valley Bean and Beet Research Farm in 2004; four agronomic trials, one disease nursery, and one large plot selection trial. All seed planted was untreated to maximize stand and seedling vigor traits inherent in the breeding germplasm. Agronomic trials were planted into Range 2, following normal fall tillage and seedbed preparations, on May 4 - 6, 2005. The remaining tests were planted on June 2. Blocking and thinning was completed by June 18. Harvest was completed by October 6, and sucrose determinations were done on brei samples taken one day later, frozen, and sent to Hilleshög for analyses. The contributions of Hilleshög and Michigan Sugar are gratefully acknowledged.

Test 05BB01: This test was conducted to re-evaluate promising first generation populations as identified in the 2004 Saginaw Valley Bean and Beet Farm agronomic trial. Thirty-seven entries (Table 1) were tested in a completely randomized block design with four replications of single 24-foot long rows. Commercial check varieties were Beta 5736 and Hilleshög E17. The majority of experimental entries were created to improve agronomic performance of elite smooth-rooted (SR) releases, through recombination and re-selection of high sucrose SR96 and SR97 with high yield rhizomania resistant EL0204. Six of the top 10 entries, ranked by Recoverable White Sucrose per Acre (RWSA) in Table 1, demonstrated the efficacy of this approach. Of the four other top 10 performers in this trial, two were checks (SR97 and B5736), and two were smooth-root populations constructed for resistance to Rhizoctonia crown and root rot. Entry 4 (Table 1) was released to industry in 2005 as EL53 (see release notice below). Entry 5 will be released as SR98 in 2006 pending additional disease resistance data. Of the remaining 27 entries tested, most were examined to select from recombined lines pairing traditional elite East Lansing germplasm derived from G. Hogaboam era materials with smooth-root. Exceptions included EL50/2, a reselection of the highly Cercospora resistant release EL50, and Hero, a potentially new Aphanomyces resistant material selected from crosses between wild and sugar beet over the past eight years. These materials will be released to industry in 2006.

In general, performance was excellent. All entries showed good to excellent emergence (Table 2). Maximal emergence for most lines occurred by 21-days after planting. The ratio of 28-day stand count to 21-day stand count is a measure of stand persistence, or alternatively a measure of seedling disease resistance, and differences here were statistically significant at the 0.1 level. Stand declines were not as pronounced in 2005 as they have been in previous years, perhaps due to the cool weather during the early season limiting loss due to Rhizoctonia seedling disease.

One observation of note is evident again in 2005 in Table 1. Water content (as a proportion of total root weight) was included in the analyses for the second time this year, and did not vary greatly among any germplasm, however differences were highly precise and robust.

Noteworthy is that the commercial germplasms B5736 and E17 had at least 1% reduced water content relative to all experimental lines and checks. The significance of this observation is not yet entirely clear, but higher dry matter (DM) content appears to be a character amenable to selection.

Table 1: Agronomic results from Test 05BB01, sorted by Recoverable White Sugar per Acre (RWSA).

Entry	Seedlot	Name	Sucrose (%)	T/A	RWSA	RWST	K	Na	Amino-N	CJP (%)	Water (%)
16	EL-A013478	BI-SR96smrIP	16.48	26.6	8710.4	329.5	5.88	1.28	2.18	96.967	75.65
13	EL-A011964	B5736	17.82	24.4	8700.5	356.5	4.83	0.93	1.39	96.977	74.18
22	EL-A013499	OB-EL0204smrIP	16.21	26.7	8648.2	324.3	5.17	1.03	1.71	96.973	76.63
8	EL-A013514	RA-01B006smrIP	15.69	27.2	8528.2	313.8	5.39	1.46	1.94	96.970	77.23
23	EL-A013501	OB-SR96smrIP	16.69	25.2	8427.1	333.9	5.03	0.88	2.24	96.970	75.70
4	EL-A013523	2xSRrzc,smr (01B024)	15.31	27.3	8366.0	306.2	5.46	0.97	1.76	96.972	77.60
10	EL-A013503	OB-SR97smrIP	16.59	24.4	8123.4	331.7	5.23	0.93	1.94	96.971	75.85
7	EL-A013507	OS-EL0204smrIP	16.05	25.1	8064.2	320.9	6.29	3.18	3.72	96.949	75.93
6	EL-A012174	SR97	16.91	23.7	8032.7	338.2	5.13	0.83	1.69	96.974	75.05
5	EL-A012176	WC970457 96RHS21-7	16.51	24.2	7983.0	330.3	4.92	0.85	1.76	96.974	75.88
26	EL-A013510	OS-SR97smrIP	17.07	22.8	7784.1	341.4	5.25	0.80	1.69	96.974	75.35
9	EL-A013495	MF-SR97smrIP	16.11	23.9	7673.6	322.1	5.28	1.02	1.97	96.971	77.23
35	EL-A013704	GH-02B096smr-IP	16.03	23.3	7461.2	320.5	5.50	1.35	2.18	96.968	77.30
12	EL-A011875	HME17	17.47	20.6	7207.0	349.5	4.04	0.70	1.77	96.976	74.13
24	EL-A013506	OS-95HS2smrIP	17.11	20.6	7054.6	342.2	4.87	0.95	1.92	96.972	75.55
25	EL-A013508	OS-SR96smrIP	17.12	20.4	6981.4	342.3	4.55	0.82	2.12	96.972	75.43
34	EL-A013700	GH-02B097smr-IP	16.46	21.2	6963.8	329.3	5.12	1.18	2.42	96.967	76.40
36	EL-A013705	GH-02B103smr-IP	15.91	21.6	6897.5	318.1	5.28	1.43	1.71	96.972	77.48
27	EL-A013515	RA-01B007smrIP	14.97	23.1	6857.4	299.4	5.80	1.89	1.89	96.968	77.88
29	EL-A013517	RA-01B010smrIP	15.72	21.8	6850.7	314.3	5.62	1.18	2.22	96.968	77.03
28	EL-A013516	RA-01B009smrIP	15.18	22.5	6841.4	303.7	5.30	1.60	1.99	96.969	77.50
19	EL-A013489	MF-Trad-ELsmrIP	15.02	22.7	6834.6	300.4	5.57	1.61	1.91	96.969	78.03
33	EL-A013522	RA-SR96smrIP	16.64	20.2	6725.7	332.9	4.87	1.01	2.14	96.970	76.03
14	EL-A011969	WC-J19	14.62	23.0	6713.0	292.4	6.37	1.31	1.48	96.972	78.00
20	EL-A013491	BI-EL0204smrIP	15.68	21.3	6671.7	313.7	5.97	1.38	2.43	96.965	77.43
11	EL-A007774	GH-01B024smr (SR Rzc)	15.14	21.8	6578.6	302.8	5.50	1.18	1.41	96.974	78.03
21	EL-A013492	MF-SR96smrIP	16.64	19.3	6405.4	332.8	5.49	0.93	1.89	96.971	76.00
15	EL-A012346	GH-99J12	16.23	19.7	6398.2	324.6	6.05	1.12	2.95	96.961	75.85
2	EL-A014205	HERO	15.62	20.2	6281.7	312.4	4.93	1.02	1.74	96.973	77.10
31	EL-A013520	RA-01B013smrIP	15.97	19.3	6165.6	319.5	4.88	1.03	1.38	96.976	76.55
30	EL-A013518	RA-01B011smrIP	15.35	19.9	6137.5	307.1	5.47	1.13	1.85	96.971	77.45
32	EL-A013521	RA-EL0204smrIP	14.91	20.4	6074.7	298.2	5.41	1.22	1.54	96.974	78.03
18	EL-A013488	MF-00J12smrIP	15.34	19.5	5915.7	306.7	5.50	1.54	2.35	96.966	77.43
3	EL-A013698	HTSLsmr (00B041)	14.58	19.7	5746.6	291.7	5.13	1.12	1.70	96.973	77.75
0	EL-A013699	00B042 (89F2-2)	16.77	16.9	5683.9	335.5	4.01	0.83	1.85	96.975	75.83
17	EL-A013480	BI-SR97smrIP	15.39	18.0	5549.0	307.7	6.15	1.62	2.94	96.960	77.10
1	EL-A014990	EL50/2	15.09	12.1	3653.9	301.8	4.94	1.07	1.69	96.974	77.53
Grand Mean			16.01	21.9	7018.7	320.2	5.3	1.2	1.98	96.97	76.62
LSD (0.05)			0.71	6.01	1901	14.2	0.85	1.15	1.28	0.014	1.56
CV (%)			5.79	21.93	22.72	5.79	13.97	69.27	46.4	0.01	1.68
F value			10.60***	2.05**	2.56***	10.60***	3.05***	1.13ns	1.05ns	1.09ns	6.87***

Table 2: Stand establishment (number of plants at each count, measured from the day of planting) for Test 05BB01. Results are sorted by the ratio of the 28-day count to the 21-day count as a measure of stand persistence.

Entry	Name	12-day	21-day	28-day	Ratio: 28/21	Final
1	EL50/2	23.0	36.3	46.8	1.30	26.3
19	MF-Trad-ELsmrIP	31.5	34.5	40.0	1.13	25.0
17	BI-SR97smrIP	18.5	20.3	22.3	1.07	12.5
24	OS-95HS2smrIP	23.0	30.5	30.8	1.04	24.8
26	OS-SR97smrIP	29.8	31.3	29.3	0.96	18.0
21	MF-SR96smrIP	30.0	31.0	29.8	0.96	17.8
30	RA-01B011smrIP	29.0	40.0	36.5	0.94	24.8
14	WC-J19	33.8	47.0	43.3	0.92	26.8
13	B5736	34.8	39.0	35.0	0.91	27.3
25	OS-SR96smrIP	31.5	40.8	33.5	0.91	25.0
20	BI-EL0204smrIP	30.8	36.0	30.3	0.87	23.5
22	OB-EL0204smrIP	44.3	53.0	45.0	0.85	32.5
15	GH-99J12	17.3	37.0	27.5	0.85	23.8
11	GH-01B024smr (SR Rzc)	31.0	51.5	41.8	0.84	34.3
2	HERO	25.3	47.0	38.8	0.84	32.3
27	RA-01B007smrIP	32.3	36.0	30.0	0.84	20.8
18	MF-00J12smrIP	17.3	21.3	16.8	0.82	16.0
28	RA-01B009smrIP	29.3	37.0	29.5	0.82	23.8
8	RA-01B006smrIP	64.8	62.5	50.0	0.80	37.3
23	OB-SR96smrIP	51.8	64.3	47.5	0.79	37.0
33	RA-SR96smrIP	25.8	31.0	23.3	0.79	21.5
12	HME17	59.3	73.3	54.8	0.78	36.8
32	RA-EL0204smrIP	31.3	38.3	29.5	0.78	25.0
34	GH-02B097smr-IP	36.3	56.5	39.5	0.76	37.0
3	HTSLsmr (00B041)	115.3	119.8	90.0	0.76	44.8
16	BI-SR96smrIP	40.8	41.5	31.3	0.76	29.3
36	GH-02B103smr-IP	33.3	54.5	36.3	0.75	27.3
9	MF-SR97smrIP	43.5	49.3	35.0	0.74	28.8
10	OB-SR97smrIP	37.3	51.3	37.5	0.73	27.5
31	RA-01B013smrIP	48.3	55.8	38.8	0.73	30.8
6	SR97	98.5	120.5	73.8	0.68	43.8
7	OS-EL0204smrIP	81.8	88.8	55.0	0.65	45.3
29	RA-01B010smrIP	37.3	45.3	28.8	0.64	25.8
5	WC970457 96RHS21-7	105.8	110.0	67.5	0.64	42.8
35	GH-02B096smr-IP	44.8	65.0	40.0	0.62	30.3
4	2xSRrzc,smr (01B024)	99.0	129.5	70.0	0.56	45.5
0	00B042 (89F2-2)	nd	nd	nd	nd	nd
Grand mean		43.51	53.50	40.41	0.83	29.19
LSD (0.05)		19.00	20.70	13.58	0.35	7.81
CV (%)		64.23	56.64	43.12	31.65	33.18
F value		14.28***	14.11***	10.13***	1.43	9.26***

Test 05BB02: This test was conducted to evaluate entries for possible inclusion into the germplasm release stream, specifically for improved seed parent germplasm. It has become apparent over the past four years that East Lansing materials based on the Cytoplasmic Male Sterility (CMS) and O-type restorer systems for hybrid seed production are deficient in a number of respects that limit their wider adoption. The first limitation has been the inability to store roots throughout the winter for the next year's seed production in field plots. This lack of storability is perhaps another manifestation of vigor related traits such as good emergence. The second limitation, in part due to lack of seed produced, has been the inability to obtain highly vigorous seed of these lines. 184 entries were grown as single rows. Emergence was dismal and the test was harvested for stecklings July 28. Most entries were originally constructed as combining ability tests by Claire Theurer (retired) and they represent a diverse array of germplasm. Future goals of these materials are to select for higher seedling vigor for release to industry.

Test 05BB04: This test was done to evaluate 440 self-fertile lines for field performance, specifically emergence and field vigor evaluation. 247 lines were selfed five generations derived from a cross between sugar beet and table (red) beet. Deep inbreds such as these are not typically used in sugar beet breeding, and the effects of inbreeding were of interest. In general, emergence and seedling vigor was not seriously affected suggesting inbreds will be useful for specific genetic investigations in the future. Yield data was not taken. Since red pigment is a genetically dominant character, many of the tested lines were pigmented. An unusual feature of many of these inbreds was that they were cylindrical in shape. When tested, their sucrose content was higher than table beet, and the combination of higher sucrose and cylindrical shape suggested a possible use for canning. These lines were combined and released to industry as TBEL-1 in 2005 (the release notice is given below). The remaining self fertile lines tested represented a wide range of early generation inbreeding populations from crosses of sugar beet with fodder beet, chard, wild beet, and a series of other sugar beets with resistance to various diseases. These represent intermediates in the development of populations that will be used to dissect agronomic traits in sugar beet, and a generation of growing under field conditions was important to remove lines with poor vigor. Three to five roots were harvested for further inbreeding and seed production in the 2006 greenhouse.

Test 05BB05 and 05BB06: These tests were conducted on ground immediately north of the irrigation pond where beet growth has historically been difficult. Late planting was desired to maximize the effect of Aphanomyces on emergence and stand establishment. Both trials were planted into dry ground on June 2, 2005. Heavy rains followed shortly thereafter, and few plants emerged. This test was abandoned, with the exception that all plants that had emerged and survived were collected for seed production in the 2006 greenhouse.

STRESS GERMINATION RING TEST WITH IIRB AND FIELD VALIDATION IN MICHIGAN

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Assistance of Bert Vandenbussche (SES), Morten Jorsboe (Dansico), Pacale Jansen (Advanta) is gratefully acknowledged.

Test 05BB03: This test was conducted to validate field emergence on commercial-grade hybrids selected by European breeding companies for a 'ring test' to evaluate the water germination stress test developed at East Lansing for predicting relative field emergence. Water and hydrogen peroxide tests were conducted prior to field emergence testing at the Bean and Beet Farm and in East Lansing, MI. Some of this information was presented to the IIRB Seed Quality and Testing Group in Seville Spain in May 2005. The entire data set is available on request.

A stress test able to predict germination and emergence of sugar beet in the field would be useful to a number workers in the industry, including seeds' people, agronomists, breeders, and growers. A number of procedures are available that have some predictive power, however field conditions are difficult to mimic in the laboratory. Germination of sugar beet seed in aqueous solutions shows promise as an additional tool for examining seedling vigor, as well as to deduce some of the underlying differences that contribute to the genetic basis of vigor and differences between seedlots of the same genetic makeup. The objective of this test was to compare results among laboratories (i.e. a ring test) for two aqueous germination regimes using a common set of seedlots.

A planning meeting was held at the IIRB office in Brussels in September 2004 to discuss experimental designs for an aqueous germination (e.g. stress) ring test. It was agreed that a number of seedlots would be tested, with at least one seedlot with high genetic potential and another with low genetic potential being contributed, at the choice and discretion of participating seed companies. Further, two seedlots for each genetic choice would be tested, one with higher emergence potential (e.g. vigor) and another with lower vigor. Thus, from each participant, four seed samples would be received; one with high genetic potential and high seedlot potential (designated **high-high**), one with high genetic potential and low seedlot potential (**high-low**), one with low genetic and high seedlot potentials (**low-high**), and one with low genetic and seedlot potentials (**low-low**). Ultimately, seedlots were generously contributed by Strube Dieckmann (SD) and SES, yielding eight experimental entries. These were designated as IIRB seedlots.

It was agreed that participants in the ring test would follow a standard protocol. The protocol chosen was to germinate 100 seeds in 40 ml of solution in a 250 ml flask at 20 C with constant agitation, suggested by shaking seed on a rotary platform at 100 rpm, with four replications of each entry. Counts of seeds with visible radicles were to be made at 48 h and 96 h after immersion, suggested with a change of solution at the first count time-point. Two solutions would be tested, one of water of discretionary quality and one of 0.3% hydrogen peroxide, freshly prepared. Results were to be recorded in a standard format Excel spreadsheet and forwarded to M. McGrath for statistical analyses. Three laboratories participated in performing the test; Danisco (c/o Morten Jorsboe), SES (c/o Bert Vandenbussche); and USDA-ARS (Kevin Cook performed the experiments with Mitch McGrath) and their efforts are gratefully acknowledged.

In general, the test(s) worked well, and confirmed the germination enhancement by hydrogen peroxide in sugar beet. Water germination was significantly different compared with hydrogen peroxide results. There was little difference in results of the basic test between laboratories, indicating good concordance and repeatability of the testing procedure. The source of commercial seed was irrelevant to the comparisons (e.g. not significant), suggesting the methods could be applied to most germplasm sources. Genetic potential was easily discriminated in water solutions (Figure 1 and data not shown). Seedlot potential was also easy to discriminate in solution, however the differences were smaller than for genetic (variety) differences (data available on request). Counting times earlier than 96 h showed less dramatic but similar trends. Lower temperature conditions appear to alter these conclusions in a number of cases suggesting an in depth focus on temperature and aqueous germination could provide additional insight into the process of stress germination.

For the field emergence tests, 100 seeds were planted in four replications at sites on the Bean and Beet Farm and on the Michigan State University Campus. Emergence counts were made 12, 19, 26, and 33 days after planting, and the average of all four counts was used here for analyses. Significant differences in emergence were not apparent at the Bean and Beet Farm (Figure 2), but they were evident at the Michigan State University site (Figure 3), and in the predicted direction.

Conclusion: Stress conditions of water germinated seeds at room temperature counted at 96 h after immersion is a good predictor of seedlot potential and a better predictor of genetic potential. These results indicate that an emergence stress test such as the one developed may help predict field emergence. The stress test appears to be more rigorous in defining genetic stress emergence potential than actual field emergence.

Figure 1: Discrimination of genetic potential for emergence of IIRB seedlots in solution. Y-axis is the number of seeds germinated in water after 96 hours of imbibition. Non-overlapping Student's t-test circles indicate statistical significance. The widest part of the diamond indicates the mean response. All data are presented as dots.

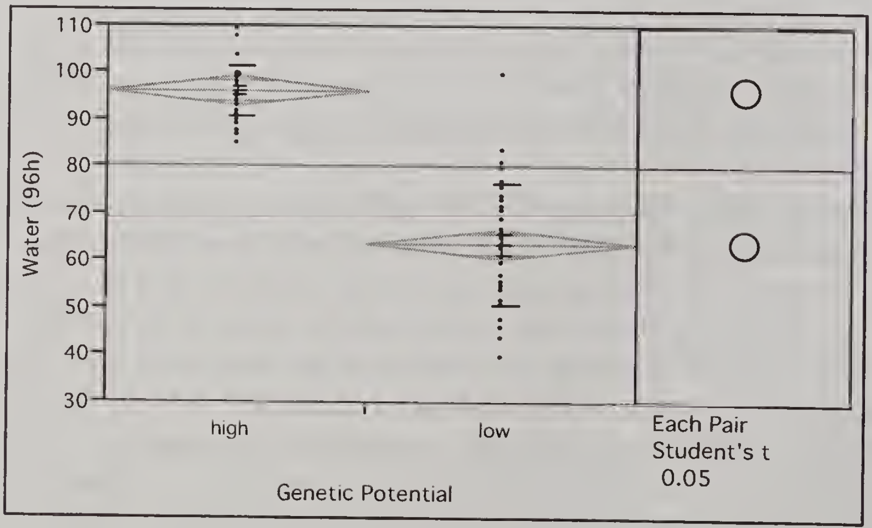


Figure 2: Emergence of IIRB seedlots at the Bean and Beet farm. Y-axis is the number of seedlings counted, averaged over four counting times. No significant difference in emergence between high and low genetic potential seedlots was obseved.

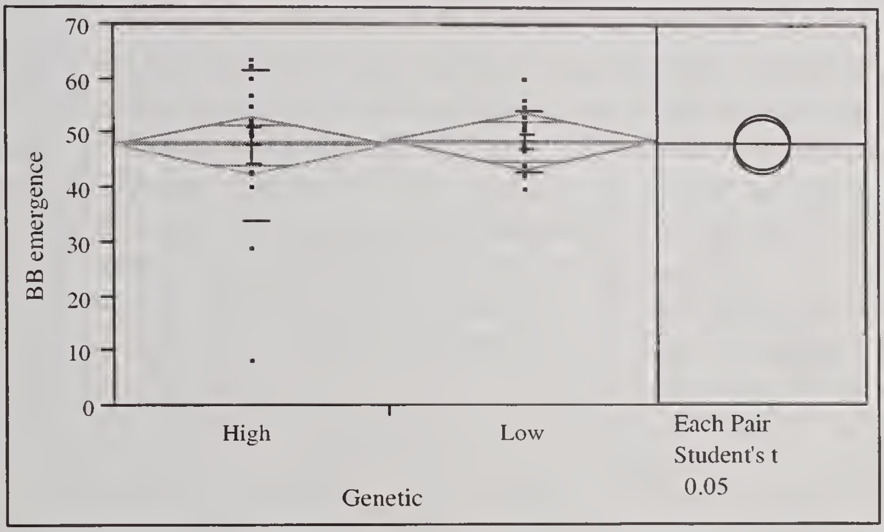
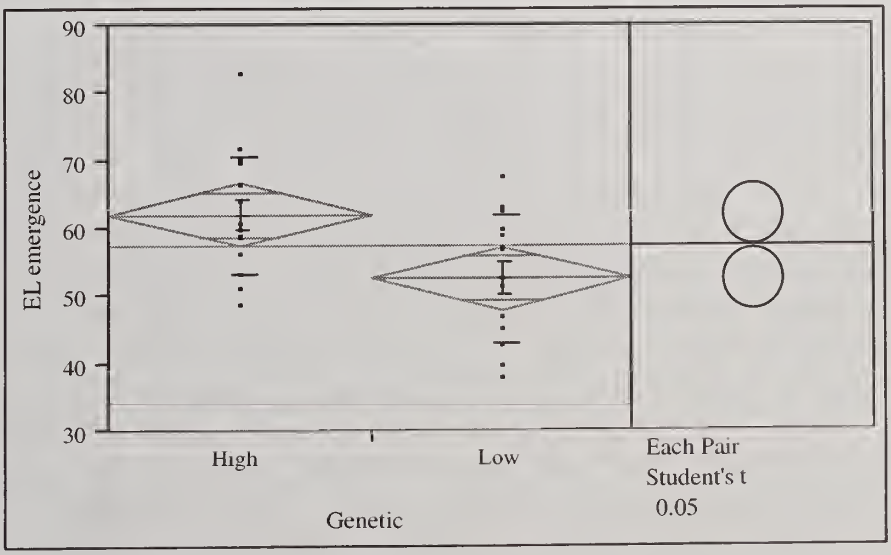


Figure 3: Emergence of IIRB seedlots at Michigan State University Farm in East Lansing. Y-axis is the number of seedlings counted, averaged over four counting times. Emergence of high and low genetic potential seedlots was significantly different ($p = 0.05$).



GENETIC RELATIONSHIPS BETWEEN QTL FOR SUCROSE CONTENT AND YIELD IN A SUGAR BY TABLE BEET (*BETA VULGARIS* L.) WIDE CROSS

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Abstract: Sucrose yield is the primary trait for sugar beet, and simply considered, is a product of the total root harvest times the percent sucrose in harvested beets. Simultaneously increasing root weight and sucrose percent in fresh beets has been problematic because of an observed inverse relationship between yield and sucrose content; however reasons for this negative correlation have not been well defined physiologically. Physiological components (sucrose content as percent of both fresh and dry root weight, and water and dry matter percent) and yield components (root, sucrose, water and dry matter weights) were measured in field-grown selfed F_3 progenies derived from a single sugar × table beet hybrid individual. This cross was chosen to maximize genetic diversity and facilitate analyses of sugar beet agronomic traits. All yield component measures were highly correlated with each other, and QTL analyses suggested each of these traits was oligogenic. Physiological component measures were not as well correlated with each other, and QTL analyses indicated that these also were oligogenic. Yield component QTLs often co-segregated with one another, and their relationship with physiological QTLs suggested at least two linkage groups harbor genes contributing to sucrose yield at both levels. Significantly, sucrose fresh weight QTLs co-segregated with either dry matter percent or sucrose percent of dry matter QTLs. Opposing alleles at oligogenic loci may explain, in part, the inverse correlation between root yield and sucrose content.

Abbreviations: CIM, Composite Interval Mapping; CPA, Comparative Phenotypic Analysis; DM, Dry Matter; H, Broad sense heritability; HSY, Harvested Sucrose Yield; QTL, Quantitative Trait Loci; RW, average Root Weight; SMA, Single Marker Analysis; SucDM, Sucrose portion of Dry Matter; SucFW, Sucrose portion of Fresh Weight; W, Water.

Introduction: Since the beginning of sugar beet cultivation as an alternate source of sucrose in human diets over two centuries ago, root sucrose content has been expressed as a percent of root's fresh weight, primarily because of the ease of refractometric measures, and later polarimetry, to gauge soluble solid content in unprocessed beet juice. Using such methods, sucrose content in beets increased from ca. 6% in the mid-18th century (Winner 1993) to 18% or more in today's hybrids. A great deal of progress has been made by traditional breeding, however the genetic dissection of sucrose content and related sucrose yield traits has been problematic for a number of reasons, including self-incompatibility (Larsen 1977) hindering development of informative genetic populations and high heterozygosity in the beet germplasm. Genetic analyses of intra-specific crosses within *Beta vulgaris* that maximize heterozygosity for agronomic phenotypes may be useful for dissecting genetic components, such as the sugar X table beet derived population used here.

Sucrose yield is the most important agronomic trait for sugar beet, and simply considered, is the percent of sucrose in the weight of harvested roots minus any sucrose losses incurred

during post-harvest storage and processing. Root sucrose content is a highly heritable quantitative trait in sugar beet, with genes acting in an additive fashion (Culbertson 1942; Powers 1957; Powers et al. 1963; Zhao et al. 1997). Additive gene action for sucrose content predominates in several other crops, including soybean, sugarcane, onion, and coffee (Ky et al. 2000; Maughan et al. 2000; Ming et al. 2001; Ming et al. 2002; Natoli et al. 2002; Havey et al. 2004), although in tomato and melon single genes appear to influence fruit sucrose content (Chetelat 1993; Burger et al. 2002). In sugar beet, Savitsky (1940) surmised three or four loci were involved in the expression of sucrose content, and Schneider et al. (2002) localized five QTL for root sugar content on five of the nine beet chromosomes. In contrast, root weight is considered predominantly due to non-additive gene action and highly influenced by environment, and it has not been as predictable during selection as sucrose content (Savitsky 1940; Bosemark 1993).

The relatively simple to measure traits of root weight per unit area and sucrose content expressed as a percentage of fresh weight have been sufficient selection indices for sugar beet population improvement. Physiologically, each trait alone is likely subject to many genetic and non-genetic influences, and an understanding of underlying genetic factors would undoubtedly influence improvement strategies, particularly in cases where introgression of novel disease resistances from wild sources into elite lines will need extensive root yield and sucrose content improvement for commercial deployment. Specifically, dissection of sucrose content as a percent of root fresh weight into components such as water content, root dry matter content, and sucrose content expressed as percentage of dry matter could reveal differences in dry matter/water content and dry matter carbohydrate partitioning between breeding lines that have remained hidden with the sole use of polarimetric analysis. Heritability and genetic variability for sucrose content as proportion of root dry matter has not previously been reported and is presented here. Genetic variability for these traits may be useful for sugar beet improvement.

MATERIALS AND METHODS:

Plant Materials: A diploid, self-fertile segregating population was derived from an intra-specific cross between sugar beet C869 (Lewellen 2004) and table beet W357B (Goldman 1996). C869 is characterized by higher root sucrose content (ca. 15% as fresh weight) and higher average root weight (RW), while line W357B is characterized by lower root sucrose content (ca .9 %) and lower RW. Both parents carried the dominant self-fertility allele (Owen 1942), while C869 also carried the monogenic nuclear male-sterility allele (Owen 1952) to facilitate making the original hybrid. From selfing a single F_1 hybrid individual, 128 F_2 plants were grown and genotyped with 246 AFLP markers generated with *Eco*RI-*Mse*I or *Pst*I-*Mse*I combinations (Trebbi 2005). AFLP marker nomenclature was based on the first letter of the enzyme used, followed by the exact selective nucleotides, then the size of the amplified fragment. Additional SSR markers were kindly mapped on this population by Dr. Britta Schultz (KWS SAAT AG, Einbeck, Germany), and used to standardize chromosome nomenclature according to Butterfass (1964) and subsequent trisomic analyses by Schondelmaier and Jung (1997). Other markers were used where available to give 319 mapped markers in total (Trebbi 2005). Linkage analyses were performed with JoinMap 3.0 (Van Ooijen and Voorrips 2001) using the Kosambi function (Kosambi 1944), and graphical representation of linkage groups were performed with MapChart 2.1 (Voorrips 2002).

Progeny-tests: Individual F_2-plant-derived F_3 progenies were evaluated in the field in two consecutive years (2002 and 2003) at the Michigan State University Agronomy Farm, East Lansing, MI, USA. Sufficient quantities of F_3 seed to perform a replicated field trial were obtained from 54 F_2 plants of the mapping population. F_3 families were planted in triplicate plots as single-rows (6 m long, 0.76 m between rows) in a randomized complete block design, grown using standard agronomic practices, thinned to 15 cm average plant spacing, and roots were harvested 19 weeks after emergence. Insufficient seed quantities prevented full replication in the second year when 13, 12 and 25 F_3 families were planted in a completely randomized design in triplicate, duplicate and non-replicated single-row plots, respectively, managed as in 2002 and harvested 18 weeks after emergence. Sugar beets SR96 (McGrath 2003) and USH20 (Coe and Hogaboam 1971) were used as check varieties during both years, while parent lines C869 and W357B were included in 2003. For each F_3 progeny, 6 representative roots were chosen, sawn longitudinally with a beet saw, their pulp (brei) was combined and homogenized, and 25 g of brei was immediately frozen in liquid N_2 and lyophilized. Traits analyzed are reported in Table 1. Correlation coefficients were calculated for each trait independently for each year. Broad-sense heritability (*H*) was also calculated for each trait and for each year as: $H = \sigma^2_g / [\sigma^2_g + (\sigma^2_e / r)]$, where σ^2_g was the genetic variance, σ^2_e was the experimental error variance, and r was the number of replications (Johnson et al. 1955; Fehr 1987), estimated via PROC MIXED (SAS, Version 8, SAS Institute, Cary, NC, USA).

QTL Analyses: Average F_3 progeny trait values were used for QTL analyses. Values were tested for normal distribution using Shapiro-Wilk's test (Shapiro and Wilk 1965) and $\log_{10}$ transformed if normality was not supported. QTL analysis was performed using QTL Cartographer 2.0 (Wang et al. 2002), analyzing data from each year separately. Single marker analysis (SMA) (Weller 1986; Stuber 1995) and composite interval mapping (CIM) (Zeng 1993; Zeng 1994) algorithms were used for QTL detection. CIM was performed using Model 6, Walking Interval = 0.5 cM, Window Size = 10 cM, and 10 markers as background control detected through forward and backward stepwise regression. Likelihood of the odds (LOD) score for QTL significance thresholds were estimated after 1000 permutations (Churchill and Doerge 1994). Each QTL interval was estimated as the region containing the maximum LOD score and encompassing ($LOD_{MAX} - 1$) on either side of the maximum. QTLs were named based on a progressive number identifier for each trait in Table 1. Phenotypic variance explained by each QTL was estimated from the coefficient of determination (R^2) obtained via CIM.

For significant QTL intervals detected with SMA or CIM, parental allele combinations effects were analyzed by visualizing F_2 genotypes with Graphical Genotype (GGT) (van Berloo 1999) and grouping F_2 genotypes according to parental allelic status within each QTL interval. Not all F_2 genotypes could be precisely determined, and only those individuals with clear sugar or table beet allele discrimination were considered. For each QTL interval, the group average F_3-derived F_2 trait value from the sugar beet-derived QTL was compared with the corresponding average of F_3-derived F_2 genotypes with the table beet-derived allele. This procedure was termed comparative phenotypic analysis (CPA), and the significance of trait differences between homozygous parental allele combinations was estimated via pooled *t*-test.

RESULTS:

Experiments were conducted for an initial understanding of genetic relationships of physiological components influencing sucrose content (i.e. sucrose content expressed as a percent root fresh or dry matter, and percent dry matter) and mass components influencing root yield (i.e. average root weight, water weight, dry matter weight, and sucrose yield). Self-pollinated segregating progenies derived from an intra-specific cross between sugar and table beets were used for the analyses. To our knowledge, this is the first report of such an approach being attempted in *Beta vulgaris*, and it was made difficult because of the unpredictable and variable seed quantities obtained from a single selfed F_2 plants (data not shown). Although the field population sizes and number of experimental replications was less than ideal, significant differences were obtained for all sucrose yield physiological and weight components, and allowed a preliminary examination of their inheritances and relationships, as well as insight into the relative importance of root dry matter content and root sucrose content as a proportion of the dry matter.

Trait Segregation: Overall yield (weight) measures were different between years, but average physiological values (percent) were similar between years (Tables 2 and 3). Relative rankings based on harvested sucrose yield (HSY) for each F_3 family varied between years, however four families were in the top ten each year and four others in the bottom ranked 10 families. Trait values showed continuous variation in both years, as expected for quantitative traits, with the exceptions of root dry matter content (%DM) and root sucrose content per fresh weight (%SucFW) in 2002.

In 2002, 54 F_3 families from which sufficient seed was obtained from the 128 F_2 plants were examined and compared with check lines whose results have been reported previously (Trebbi and McGrath 2004), and included in Table 2 for comparison. All traits except sucrose as a percent of dry matter (%SucDM) showed significance with Fisher's test statistic. For instance, F_3 progenies means for HSY ranged from 32 to 124 g plant^{-1}, and progeny with high (lines 38a and 92a) and low (lines 89a, 71 and 75) HSY also showed high and low values of each other weight component, respectively (Table 2). Sucrose percent as dry matter (%SucDM) ranged from 49.2% to 70.8%, but despite this large range of variability, its overall *F*-test was not significant (Table 2). However, pairwise comparisons for %SucDM showed significant differences between individual progenies ($LSD_{0.05} = 10.86$).

In 2003, seed quantities were limited for the majority of F_3 progeny for a fully replicated trial, however we felt strongly that the data would be valuable despite this limitation. Relationships of HSY with weight and physiological components were similar to those observed in 2002 (Table 3). However, in all cases of weight-related traits, at least one F_3 progeny was similar or transgressed the extremes of those of either parent. In contrast, measures for physiological traits were similar or transgressive only with respect to the table beet parent and only rarely approached the value of the sugar beet parent. As seen for the previous year, during 2003 all traits except %SucDM showed significant *F*-test differences between progenies, but again significant differences were detected via pairwise comparisons ($LSD_{0.05}$ = 5.8, 7.1, or 10.1 depending on 3, 2, or 1 replicates, respectively, in one or more pairwise comparison).

Trait Correlations and Heritability Estimates: Correlation coefficients (*r*) between phenotypic values for each trait were similar in both years (Table 4). All weight components were highly correlated between one another. The best predictor of HSY was dry matter

weight (DM) with $r > 0.94$ in both years. Similarly, water weight (W) and average root weight (RW) were highly correlated with HSY (r values between 0.83 and 0.91) and highly correlated among each other ($r > 0.99$ in both years) (Table 4). Physiological components were not as strongly correlated among each other or with yield components (Table 4). Interestingly, %DM was weakly correlated, with opposite effects in each year, with %SucDM, suggesting these two traits influencing %SucFW may be under independent genetic control (Table 4).

Correlation analyses between weight and physiological components showed a weak negative correlation between RW and %SucFW, not statistically significant, in both years (Table 4). A weak but statistically significant positive correlation was observed between HSY and all physiological components. Broad sense heritability estimates for each trait were similar and generally high in both years, with water and dry matter weights heritability values markedly lower than those for other traits, suggesting a large environmental effect on their expression in this population during the two growing conditions (Table 4).

Map and QTL Analyses: The genetic map consisted of 319 markers linked on nine linkage groups, spanning a total of 512.2 cM and with average inter-marker distance of 1.6 cM (Trebbi 2005). Traits %DM and %W were considered as one for QTL analysis (%DM/W loci) since their arithmetic sum is equal to 100 by definition (Table 1) and running each trait separately gave identical results. Despite the experimental limitation due to seed quantity in 2003, many QTL were surmised at similar chromosomal locations in both years, but the statistical significance, magnitude, and proportion of trait variation explained (R^2) were different between years (Table 5). A total of 33 QTLs were detected (Table 5 and Figure 1). Relatively similar numbers of QTLs were detected for each trait. Four QTLs each were detected for HSY, RW and W, while three QTLs were detected for DM. Physiological traits showed five, six and seven QTL for % SucDM, %DM/W and % SucFW, respectively.

Of the total 33 loci detected, 15 (45%) were associated with weight traits and 18 (55%) with physiological traits; while 12 (36%) were detected in 2002, 7 (21%) in 2003, and 14 (39%) in both years (Table 5). Of the 33 QTL detected, 29 (88%) were statistically significant using SMA, 23 (70%) were significant after permutation analyses with CIM, and 21 (64%) with comparative phenotypic analysis (CPA) in at least one of the two years. A total of 12 (36%) QTL were significant with all methods applied, and three of these (W-1, HSY-1, RW-1 on chromosome II) were detected in both years (Table 5). Data for non-significant CIM QTL loci, but significant with SMA, were also presented in Table 5 (in parentheses) because some of these may provide a comparison for future QTL analyses. The sugar beet parent contributed alleles with positive effect on sucrose yield for all traits considered when CPA analyses detected significant differences between homozygous classes (Table 5).

Aspects of the distribution of QTL on the map were quite striking, since yield and physiological components loci tended to cluster independently (Figure 1). Yield component QTLs (RW, W and DM) were clustered in five groups on chromosomes II, VI, VII, VIII, and IX. Similarly, physiological component QTL (%DM/W, %SucDM, and % SucFW) were mainly clustered in seven groups on chromosomes I, II, III, IV, V and two on VII. Interestingly, %SucFW loci were present in each physiological trait cluster, and always co-segregated with a QTL for %DM/W (4 instances) or %SucDM (3 instances). The four HSY

QTLs co-localized with weight component clusters on chromosomes II, VII and IX, and with physiological component clusters on chromosome III and VII, indicating the importance of both classes of traits on final sucrose yield level. Interestingly, QTLs for all sucrose yield components co-segregated to short intervals on chromosomes II and VII (Figure 1).

Discussion: Selection for increased fresh weight sucrose content and total root yield has been sufficient over the past two centuries to improve sucrose yield in sugar beet breeding programs. However, it appears nearly unanimous from the literature that a strong negative correlation between sucrose content and root yield exists, suggesting that gains in one character will be offset by losses in the other (Pritchard 1916; Powers 1957; Bergen 1967; Hecker 1967; Oldemeyer 1975; Doney et al. 1981; Carter 1987; Geidel et al. 2000). Carter (1987) provided 11 years of field data for root weight, sucrose content (per fresh and dry weights) and the combined sucrose yield of sugar and fodder beets, and concluded that much of the inverse correlation could be explained by differences in water content, as an example of one component influencing both root yield and sucrose content. However, Simmonds (1994) suggested that negative trait correlations, for example between sucrose content and root yield in sugar beet, are an artifact of simultaneous trait selection in elite lines, typical of plant material in the late stages of breeding programs when only superior lines are intercrossed (Gravois 1991). If so, then strong negative correlations may not be evident in segregating populations derived from wider crosses. Schneider et al. (2002) observed only a weak (positive) correlation between root yield and fresh weight sucrose content among experimental hybrids, suggesting that the negative correlation is not always strongly evident. This raises the possibility that one or more genetic components of sucrose yield act in opposition in elite materials, and that factoring these components could provide clues as to the nature of the negative correlation.

The development of genetic maps for QTL analysis has been very useful to identify genes responsible for important traits in sugar beet (Schafer-Pregl et al. 1999, Nilsson et al. 1999). The genetic map obtained here showed a high density and uniformity of markers on nine *B. vulgaris* linkage groups (Trebbi 2005). The wide cross between sugar and table beet lines maximized the variability of sucrose traits, facilitating phenotypic correlation and QTL analyses. QTL analyses were performed independently per each year. Heritability estimates were sufficiently high to consider QTL analysis to detect the location of at least some genes influencing root sucrose content and yield in beet.

Recently, Weber et al. (2000) found QTL for root sucrose content and yield were located in different genomic regions in diverse sugar beet populations grown in different locations. Schneider et al. (2002) also mapped QTL related to sucrose content and root yield in sugar beet using populations derived from elite lines grown at several locations but not all the QTL were detected in all locations. Similar variability was observed during our study, and correspondence between QTL locations can be partially inferred with results of Schneider et al. (2002). Schneider et al. (2002) mapped five sucrose content QTLs (directly analogous to %SucFW) on chromosomes I, II, VI, VII, and IX, and three of seven detected here were also on chromosomes I, II and VII. A sucrose yield QTL was found on chromosome IX in both studies near the end of one chromosome arm, and in our study this region also showed a root weight locus. It should be noted that different marker sets were used in the two studies and a precise association between loci would be speculative.

The high correlation coefficients observed between weight-related components and sugar yield suggests an intimate genetic association between root weight and sugar yield, supporting the assertion that the most efficient means to genetically improve sugar yields, either in elite germplasm or in return to agronomic performance after introgression with wild germplasm, is to simply increase root weight. As mentioned earlier, the genetic control of root weight appears to be non-additive and is it is difficult to effect positive selection for this trait (Geidel et al. 2000). An unexpected result of the present study was a high level of root weight heritability, perhaps as the consequence of the wider cross than typically used, or perhaps due to sampling error and experimental uncertainty from the limited number of trials and replications used here. As mentioned above, mother root or mass selections for increased root yield have not traditionally been effective, and much breeding effort is expended on progeny tests and testing for specific combining ability. Partitioning root weight characters into their respective components may allow dissection of the non-additive genetic control of root yield and better precision in selection, either at the phenotypic level of dry matter yield or content or at the molecular level by cloning genes for the QTLs and ascertaining the effect of genetic diversity substitutions on sucrose yield. Interestingly, yield genes appeared interspersed with physiological genes on chromosomes II and VII, making these genomic regions more interesting because of the potential for such regions to be involved in the association between sucrose content and yield in sugar beets. It is possible that such genomic regions would harbor genes that act in opposition for higher sucrose yield breeding targets, and perhaps in the sugar beet *per se*, such genes show relatively little genetic diversity.

To our knowledge, the genetics of sucrose yield physiological trait components %DM and %SucDM have not been examined. Significantly, QTLs for sucrose content as fresh weight (%SucFW) always co-segregated with either %DM or with %SucDM QTLs, in roughly equal proportions, supporting the assertion that sucrose fresh weight can be divided into at least two sub-components. By definition, percent dry matter was complementary to percent water and root dry matter content arguments are thus also relevant for water content. Significant and consistent differences in %DM were reported by Bergen (1967) between two varieties, characterized by extreme and opposite values of root yield and sucrose content, over two years at eight harvest dates throughout each growing season. Our results also indicated that a significant differences in %DM between F_3 lines existed, and that the correlation between %DM and %SucFW was high, significant and positive. These results strongly suggest a genetic basis for %DM. The physiological reason for higher root dry matter content has been in part related to cell size, with many smaller cells presenting the possibility of higher dry matter content than fewer large cells within the beet root (Milford 1973; Wyse 1979; Doney et al. 1981).

Sucrose content as a proportion of total dry matter (%SucDM) has also been of interest, but its relationships with fresh weight sucrose content have not been clear. Bergen (1967) did not find significant differences in %SucDM between two varieties characterized by different root yield and sucrose content, and Wyse (1980) was also unable to uncover significant changes in %SucDM by manipulating growth by reducing light intensity or augmenting CO_2 levels to alter photosynthate partitioning. Both Milford (1973) and Wyse (1979) demonstrated that %SucDM increased in the early part of the growing season but essentially remained constant after the first 10 to 14 weeks of growth. In the present study, %SucDM

was moderately and positively correlated with %SucFW and HSY, and a strong genetic basis for this trait was suggested by the high heritability value and the detection of three QTLs in both years. Overall, statistical significance for %SucDM differences between F_3 lines was not supported by an F-test in either year, but significant pairwise differences between lines were found in both years. Since the range of values of %SucDM between F_3 lines was wide, reasons for the overall lack of significant differences could have arisen from a number of causes. First, heterozygosity within each F_3 progeny line could have contributed to high phenotypic variation, and if so this could be addressed with further inbreeding. In fact, in more advanced inbred populations (F_5) derived from this material, overall F-tests were statistically different for %SucDM (data not shown). Second, experimental uncertainty could have been excessive due to the lack of statistical power in the field design, in which case further testing with greater experimental replication would be required. This could help to explain the wide differences in correlation coefficients relative to this trait between 2002 and 2003, where in 2003 experimental designs were biased due to a lack of sufficient seed for many entries. And finally, the %SucDM trait could itself be a relatively complex trait with contrasting effect alleles contributing equally by the sugar beet and table beet parents, implying a lack of selection specifically for this trait, that may help to explain its relatively high standard deviations within experimental lines when compared with other physiological traits. The importance of %SucDM as a breeding index remains uncertain, but although it does not have as a strong an influence on sucrose yield as root yield does, its contribution to increase %SucFW could be significant.

Interestingly, both %DM and %SucDM, which both influence %SucFW, are not correlated with one another, and independent selection for each trait could accelerate recovery of high sucrose yield after introgression of favorable alleles from wild germplasm, for instance. A technological change will be required to analyze dry matter components of the sugar beet if such traits are to be useful for breeding purpose, as current methods of post-harvest drying tissues are laborious and time consuming, from a breeding and selection standpoint. Near-InfraRed spectroscopy (NIR) (Roggo et al. 2002) for physiological traits, integrated with root weight (RW) measurements, could give real-time information on physiological components of sucrose yield, and provide copious information on relationships between physiological and yield components in sugar beet.

Figure 1: QTL locations for root dry matter and water content (%DM/W), root sucrose content per dry matter (%SucDM), root sucrose content per fresh weight (%SucFW), average root weight (RW), dry matter weight (DM), water weight (W), and harvestable sucrose yield (HSY). Black and white vertical bars refer to QTL intervals detected with CIM during 2002 and 2003, respectively. Black and white arrows refer to QTL position detected with SMA during 2002 and 2003, respectively. Genetic distance is cM. Linkage groups are numbered according to Schondelmaier and Jung (1997).

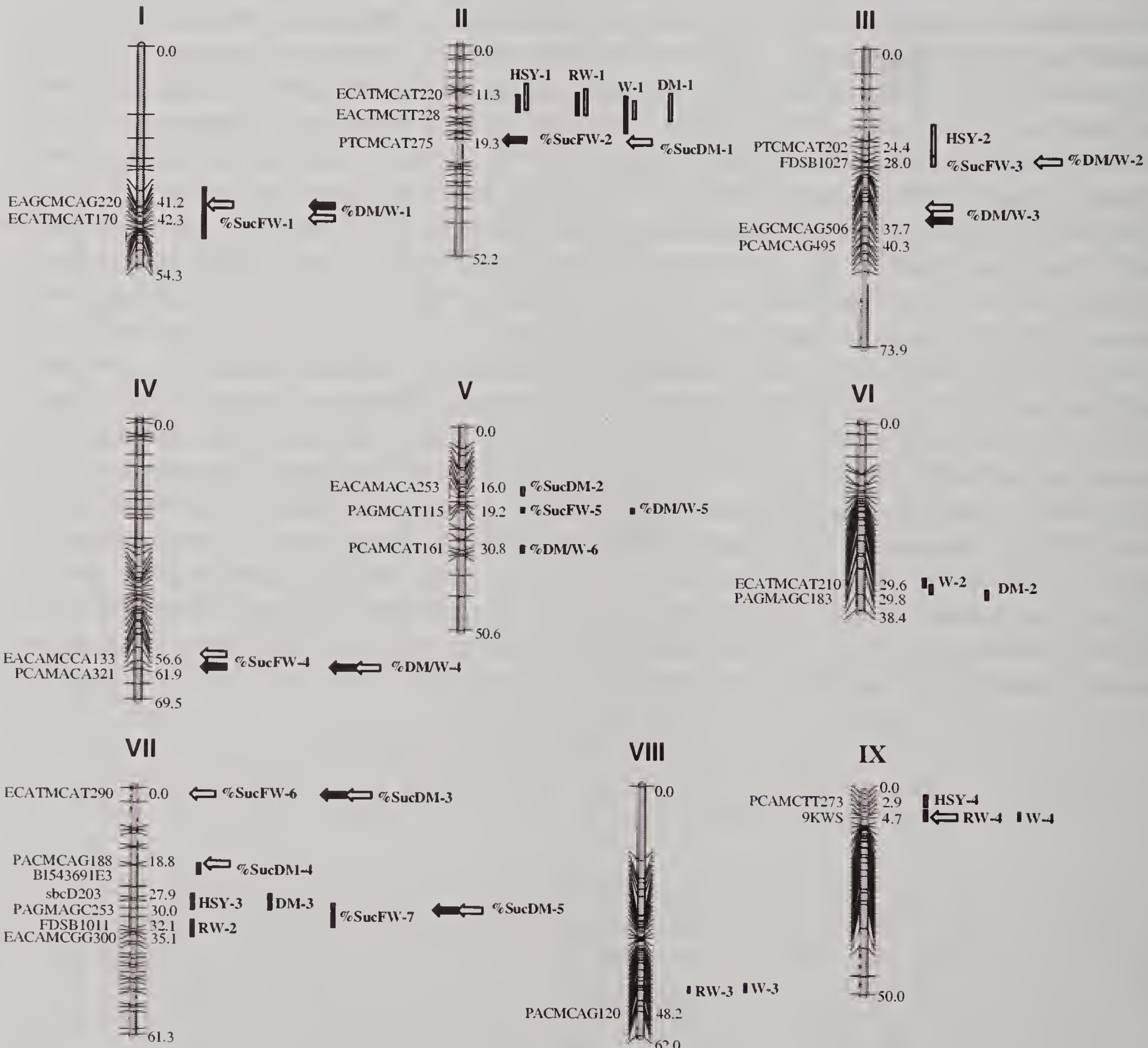

Table 1: Description of measured traits, their symbols and units used in the text, and the formulas used to calculate the reported values.

Trait	Symbol	Unit	Formula[a]
Root dry matter content	%DM	%	$\%DM = (wt_a / wt_b) \times 100$
Root water content	%W	%	$\%W = 100 - \%DM$
Root sucrose content per dry matter	%SucDM	%	([b])
Root sucrose content per fresh weight	%SucFW	%	$\%SucFW = (\%DM \times \%\ SucDM) /100$
Average root weight	RW	g $root^{-1}$	$RW = W_r / n_r$
Dry matter weight	DM	g $root^{-1}$	$DM = RW \times \%DM$
Water weight	W	g $root^{-1}$	$W = RW \times \%W$
Harvestable sucrose yield	HSY	g $root^{-1}$	$HSY = RW \times \%SucFW$

[a] wt_a = weight after lyophilization; wt_b = weight before lyophilization; Wr = root weight per plot; n_r = roots per plot

[b] measured via enzymatic-fluorometric assay (Trebbi and McGrath 2004).

Table 2: Summary and statistics for field-grown, three full replication F3 progeny test in 2002. Traits measured were harvestable sucrose yield (HSY, g plant-1), average root weight (RW, g plant-1), water weight (W, g plant-1), dry matter weight (DM, g plant-1), root water content (%W), root dry matter content (%DM), root sucrose content per dry matter (%SucDM), and root sucrose content per fresh weight (%SucFW). SD = standard deviation. *** and 'ns' refer to significant differences at $p<0.001$ and not significant, respectively.

F_3 Line	HSY	SD	RW	SD	W	SD	DM	SD	%W	SD	%DM	SD	%SucDM	SD	%SucFW	SD
38a	124	19	933	109	721	68	211	50	77.5	3.0	22.5	3.0	59.5	8.8	13.3	2.1
92a	124	38	1,063	453	856	415	207	48	79.1	5.0	20.9	5.0	59.4	8.7	12.1	1.6
116a	110	12	912	76	763	65	149	11	83.7	0.4	16.3	0.4	70.8	4.7	11.5	1.1
110a	108	5	930	151	743	140	187	14	79.7	2.5	20.3	2.5	58.2	4.0	11.9	2.3
93	107	21	874	40	701	12	173	36	80.3	3.2	19.7	3.2	59.4	3.0	12.2	1.6
107	107	8	975	109	783	126	193	22	80.0	4.0	20.0	4.0	55.8	2.3	11.1	1.8
127	106	13	928	69	745	59	183	17	80.3	1.4	19.7	1.4	58.0	4.4	11.4	0.6
82a	105	28	911	68	734	43	177	35	80.7	2.7	19.3	2.7	58.9	7.8	11.4	2.4
103	104	20	1,078	182	901	149	176	33	83.7	0.4	16.3	0.4	58.9	4.1	9.6	0.5
125	102	13	984	85	798	59	186	27	81.1	1.1	18.9	1.1	54.9	2.8	10.3	0.6
72a	97	22	828	58	670	24	158	39	81.1	3.4	18.9	3.4	61.9	9.8	11.6	1.9
86	96	23	870	101	703	64	166	40	81.0	2.5	19.0	2.5	52.7	0.4	10.4	1.7
121	95	11	806	30	641	50	176	18	78.4	3.0	21.6	3.0	57.9	6.7	11.7	1.8
63	95	25	822	54	658	50	164	28	80.0	3.1	20.0	3.1	57.2	8.1	11.4	2.5
117a	92	55	853	470	697	385	156	86	81.6	0.6	18.4	0.6	58.3	6.2	10.7	1.4
73	90	11	796	129	633	126	163	26	79.2	3.9	20.8	3.9	55.3	4.6	11.5	2.5
123a	86	12	824	54	684	52	140	5	83.0	1.0	17.0	1.0	61.6	8.4	10.4	0.8
101	85	12	654	103	508	106	146	5	77.3	3.8	22.7	3.8	57.3	10.1	14.2	2.3
99	84	9	837	52	675	48	162	25	80.7	2.8	19.3	2.8	52.3	2.9	10.1	0.8
27	80	20	609	132	478	107	131	40	78.5	5.1	21.5	5.1	62.1	4.0	13.3	3.1
33	78	24	702	106	565	70	137	41	80.8	3.1	19.2	3.1	57.0	3.1	10.9	1.8
111	76	27	718	228	585	195	133	34	81.1	2.1	18.9	2.1	56.4	5.6	10.6	1.0
119a	76	20	745	136	602	103	142	33	81.0	1.0	19.0	1.0	53.2	3.5	10.1	0.9
104	76	6	836	141	695	120	142	21	83.0	0.9	17.0	0.9	53.7	7.3	9.4	1.5
94	75	19	693	92	548	62	146	30	79.1	1.6	20.9	1.6	50.8	2.5	10.6	1.3
84a	74	5	658	141	521	134	137	11	78.6	4.4	21.4	4.4	54.1	3.1	11.5	2.0
35	73	8	629	26	494	21	135	23	78.6	3.2	21.4	3.2	54.3	5.0	11.5	0.9
76a	73	18	656	93	517	59	139	39	79.0	3.2	21.0	3.2	53.1	2.1	11.1	1.2
105a	73	1	736	117	598	115	137	4	81.0	3.1	19.0	3.1	52.8	2.2	10.0	1.8
84	72	1	584	38	455	35	129	16	77.9	2.6	22.1	2.6	56.2	6.0	12.3	0.8
72	72	16	652	76	515	51	137	28	79.1	2.3	20.9	2.3	52.3	4.0	10.9	1.2
99a	72	27	739	100	612	55	126	46	83.2	3.7	16.8	3.7	56.9	5.6	9.6	2.3
73a	70	32	575	191	454	149	121	45	79.1	3.2	20.9	3.2	56.7	5.1	11.9	2.5
31	70	26	696	182	566	135	131	49	81.5	2.7	18.5	2.7	53.6	1.6	9.9	1.2
29a	70	11	678	123	542	94	136	30	80.0	0.8	20.0	0.8	49.2	5.3	9.8	0.5
39a	69	12	644	129	534	118	110	18	82.6	3.1	17.4	3.1	62.1	3.1	10.7	1.3
71a	67	6	618	36	498	25	120	12	80.6	0.9	19.4	0.9	56.3	10.9	10.9	1.6
93a	62	22	552	145	445	119	107	26	80.6	0.8	19.4	0.8	56.6	7.2	11.0	1.3
122a	62	32	670	169	558	139	113	32	83.3	1.4	16.7	1.4	56.4	7.2	9.8	2.1
27a	62	4	681	139	554	113	128	26	81.3	0.4	18.7	0.4	49.2	6.9	9.2	1.2
77	62	8	686	90	566	71	119	20	82.6	0.7	17.4	0.7	52.6	6.2	9.1	1.0
42a	61	9	532	125	417	118	116	16	77.8	4.1	22.2	4.1	53.0	6.0	11.6	1.0
78a	61	17	589	195	483	174	107	21	81.2	3.3	18.8	3.3	56.7	6.8	10.5	0.9
66	60	10	500	36	398	49	102	15	79.4	4.4	20.6	4.4	58.8	2.8	12.2	3.0
76	59	14	550	90	444	82	107	19	80.5	3.4	19.5	3.4	55.2	4.2	10.8	2.1
79	59	19	582	147	477	121	105	27	81.9	0.7	18.1	0.7	55.8	3.7	10.1	0.8
96	58	7	611	36	508	28	103	9	83.2	0.8	16.8	0.8	56.6	1.8	9.5	0.7
59a	56	12	574	137	463	119	111	18	80.4	2.2	19.6	2.2	50.2	4.0	9.9	1.5
65	56	19	585	137	471	95	114	44	80.9	3.0	19.1	3.0	49.6	4.6	9.4	1.0
43a	52	8	616	194	421	96	91	8	82.0	2.1	18.0	2.1	56.2	2.5	10.2	0.6
95a	49	10	623	109	528	92	95	17	84.8	0.6	15.2	0.6	51.9	1.5	7.9	0.3
75	46	3	460	94	375	87	85	16	81.2	4.1	18.8	4.1	54.4	7.8	10.2	2.0
71	41	10	318	74	245	60	72	19	77.1	3.8	22.9	3.8	56.4	3.5	12.9	1.4
89a	32	1	351	92	288	87	63	6	81.4	3.8	18.6	3.8	53.4	0.2	10.6	2.2
Mean	77	25	713	202	575	169	137	41	80.6	2.9	19.4	2.9	55.9	5.7	10.9	1.8
F value	3.35***		3.85***		3.68***		3.41***		2.85***		2.85***		1.26^{ns}		2.94***	
SR96	145	35	1056	273	812	248	244	25	75.5	3.0	24.5	3.0	58.1	6.0	14.1	0.7
US H20	212	76	1407	430	1112	334	294	97	79.1	1.0	20.9	1.0	71.2	3.8	14.8	1.1

Table 3: Summary and statistics for the field-grown F_3 progeny test during 2003. Traits measured were harvestable sucrose yield (HSY, g plant^{-1}), average root weight (RW, g plant^{-1}), water weight (W, g plant^{-1}), dry matter weight (DM, g plant^{-1}), root water content (%W), root dry matter content (%DM), root sucrose content per dry matter (%SucDM), and root sucrose content per fresh weight (%SucFW). Reps is the number of replications. SD = standard deviation. na = not applicable. ***, ** and ns refer to differences significant at $p<0.001$, $p<0.01$ and not significant, respectively.

F_3 Line	Reps	HSY	SD	RW	SD	W	SD	DM	SD	%W	SD	%DM	SD	%SucDM	SD	%SucFW	SD
117a	2	162	6	1,377	27	1,096	20	280	6	79.6	0.1	20.4	0.1	57.9	0.8	11.8	0.2
116a	1	162	na	1,498	na	1,226	na	272	na	81.9	na	18.1	na	59.7	na	10.8	na
82a	2	157	13	1,269	66	1,017	72	252	5	80.1	1.5	19.9	1.5	62.2	3.8	12.4	1.7
125	1	153	na	1,186	na	938	na	248	na	79.1	na	20.9	na	61.7	na	12.9	na
38a	3	147	46	1,162	346	927	271	235	75	80.4	1.1	19.6	1.1	60.4	3.6	11.9	1.3
84a	1	141	na	1,184	na	961	na	223	na	81.2	na	18.8	na	63.2	na	11.9	na
71a	1	137	na	1,004	na	788	na	216	na	78.5	na	21.5	na	63.6	na	13.7	na
122a	1	134	na	1,275	na	1,039	na	236	na	81.5	na	18.5	na	56.9	na	10.5	na
76	1	131	na	1,145	na	905	na	241	na	79.0	na	21.0	na	54.6	na	11.5	na
94	1	131	na	1,088	na	858	na	230	na	78.9	na	21.1	na	57.1	na	12.1	na
99	3	127	46	998	314	789	251	209	63	79.0	0.4	21.0	0.4	60.0	4.3	12.6	0.7
105a	3	124	44	1,171	299	964	236	207	64	82.5	0.9	17.5	0.9	59.2	3.7	10.4	1.2
35	1	123	na	1,467	na	1,235	na	232	na	84.2	na	15.8	na	53.0	na	8.4	na
73a	2	122	22	951	112	756	82	194	31	79.6	0.8	20.4	0.8	62.7	1.4	12.8	0.8
92a	1	122	na	1,330	na	1095	na	235	na	82.3	na	17.7	na	51.6	na	9.1	na
111	1	120	na	976	na	792	na	184	na	81.2	na	18.8	na	65.6	na	12.4	na
110a	1	118	na	1,006	na	814	na	192	na	81.0	na	19.0	na	61.8	na	11.8	na
93	2	118	5	1,032	130	833	106	199	23	80.7	0.2	19.3	0.2	59.7	4.4	11.5	0.9
103	3	115	23	1,194	187	988	174	206	21	82.6	2.1	17.4	2.1	55.4	5.7	9.6	1.1
123a	1	104	na	957	na	783	na	173	na	81.9	na	18.1	na	59.9	na	10.9	na
104	3	103	14	835	70	671	55	164	16	80.3	0.4	19.7	0.4	62.3	2.7	12.3	0.7
77	2	102	27	894	187	733	160	161	26	81.9	0.8	18.1	0.8	62.4	6.8	11.3	0.7
27	2	101	22	857	197	697	161	160	36	81.3	0.1	18.7	0.1	63.4	0.7	11.8	0.2
93a	1	100	na	865	na	692	na	173	na	80.0	na	20.0	na	57.6	na	11.5	na
72a	3	99	27	1,027	224	845	183	182	42	82.3	0.6	17.7	0.6	54.3	3.9	9.6	1.0
63	3	99	29	907	261	740	210	167	51	81.6	0.5	18.4	0.5	59.5	0.6	10.9	0.3
59a	1	96	na	771	na	609	na	162	na	79.0	na	21.0	na	59.5	na	12.5	na
78a	2	96	26	1,076	298	906	249	170	49	84.2	0.2	15.8	0.2	56.5	0.9	8.9	0.0
73	2	95	12	1,145	213	971	196	174	17	84.7	1.4	15.3	1.4	54.4	1.4	8.3	0.5
33	3	94	29	839	254	683	204	156	51	81.5	0.5	18.5	0.5	61.0	2.8	11.3	0.4
107	3	94	33	935	460	770	385	165	75	82.1	1.5	17.9	1.5	58.8	5.2	10.5	1.4
43a	2	94	16	842	119	672	102	170	17	79.8	0.9	20.2	0.9	55.4	4.1	11.2	0.4
65	2	92	6	855	204	690	170	165	34	80.6	0.7	19.4	0.7	56.4	7.8	11.0	1.9
96	2	90	24	747	180	597	138	150	42	80.0	0.8	20.0	0.8	60.0	0.9	12.0	0.3
86	1	89	na	874	na	711	na	163	na	81.4	na	18.6	na	54.6	na	10.2	na
101	3	85	6	789	66	639	52	149	15	81.1	0.4	18.9	0.4	56.8	2.0	10.7	0.2
121	1	79	na	726	na	600	na	127	na	82.6	na	17.4	na	62.6	na	10.9	na
76a	3	77	7	732	19	605	8	127	10	82.6	1.0	17.4	1.0	60.1	2.0	10.4	0.7
72	1	75	na	754	na	607	na	147	na	80.5	na	19.5	na	51.0	na	9.9	na
84	1	74	na	675	na	543	na	132	na	80.4	na	19.6	na	56.0	na	11.0	na
39a	3	73	10	739	94	610	73	130	21	82.5	0.6	17.5	0.6	56.5	1.2	9.9	0.1
119a	1	65	na	576	na	463	na	112	na	80.5	na	19.5	na	57.6	na	11.3	na
89a	2	56	12	579	89	477	71	102	18	82.3	0.3	17.7	0.3	54.5	2.3	9.6	0.6
42a	1	55	na	513	na	415	na	98	na	80.8	na	19.2	na	55.7	na	10.7	na
95a	1	55	na	496	na	407	na	90	na	82.0	na	18.0	na	61.1	na	11.0	na
66	1	55	na	423	na	335	na	88	na	79.3	na	20.7	na	62.3	na	12.9	na
71	3	50	20	422	167	342	134	80	33	81.1	1.2	18.9	1.2	63.4	2.5	12.0	0.5
99a	1	49	na	505	na	414	na	91	na	81.9	na	18.1	na	53.9	na	9.7	na
75	1	48	na	447	na	366	na	81	na	81.9	na	18.1	na	59.6	na	10.8	na
79	1	39	na	408	na	336	na	72	na	82.3	na	17.7	na	54.1	na	9.6	na
Mean		100	34	914	290	743	238	171	55	81.2	1.5	18.7	1.5	58.7	4.0	11.0	1.3
F-value		2.37**		2.31**		2.30**		2.46**		3.91***		3.91***		1.48^{ns}		3.19***	
6869	3	158	28	1015	142	777	129	238	39	76.5	0.7	23.5	0.6	66.5	1.4	15.6	0.6
W357B	3	38	8	437	84	363	77	73	26	83.2	0.5	16.8	0.6	51.5	1.2	8.7	0.4
SR96	3	155	26	963	154	718	118	245	37	74.6	0.7	25.4	0.7	63.1	1.3	16.0	0.5
USH20	3	138	22	918	146	709	113	209	34	77.2	0.6	22.8	0.6	65.9	1.6	15.0	0.6

Table 4: Correlation coefficients and broad-sense heritability (*H*) of progeny-tests for average root weight (RW), water weight (W), dry matter weight (DM), harvestable sucrose yield (HSY), root water content (%W), root dry matter content (%DM), root sucrose content per dry matter (%SucDM), and root sucrose content per fresh weight (%SucFW). ***, **, * and ns refer to differences significant at $p<0.001$, $p<0.01$, $p<0.05$ and non significant, respectively.

Year	Trait[a]	W	DM	HSY	%W	%DM	%SucDM	%SucFW	*H*
2002	RW	0.993***	0.871***	0.879***	0.182*	-0.182*	0.243**	-0.028ns	*0.87*
	W	-	0.806***	0.829***	0.292***	-0.292***	0.266***	-0.116ns	*0.49*
	DM		-	0.944***	-0.299***	0.299***	0.107ns	0.334***	*0.45*
	HSY			-	-0.198*	0.198*	0.419***	0.435***	*0.84*
	%W				-	-1.000***	0.211**	-0.798***	*0.65*
	%DM					-	-0.211**	0.798***	*0.65*
	%SucDM						-	0.413***	*0.78*
	%SucFW							-	*0.75*
2003	RW	0.998***	0.957***	0.914***	0.041ns	-0.041ns	-0.071ns	-0.057ns	*0.89*
	W	-	0.936***	0.888***	0.105ns	-0.105ns	-0.091ns	-0.111ns	*0.43*
	DM		-	0.977***	-0.239*	0.239*	0.017ns	0.183ns	*0.46*
	HSY			-	-0.297**	0.297**	0.219*	0.339**	*0.87*
	%W				-	-1.000***	-0.277**	-0.841***	*0.73*
	%DM					-	0.277**	0.841***	*0.73*
	%SucDM						-	0.751***	*0.76*
	%SucFW							-	*0.80*

Table 5: QTL analyses performed with single marker analysis (SMA), composite interval mapping (CIM), and comparative phenotypic analysis (CPA) on average root weight (RW), water weight (W), dry matter weight (DM), harvestable sucrose yield (HSY), root dry matter and water content (%DM/W), root sucrose content per dry matter (%SucDM), and root sucrose content per fresh weight (%SucFW). QTL were analyzed independently during 2002 and 2003. Chr. = Chromosome; ns = non-significant ($p > 0.05$).

Footnotes:
[a] Marker nomenclature follows Trebbi (2005).
[b] Significance at $p<0.05$, 0.01 and 0.001 for *, ** and ***, respectively.
[c] Genetic map position of the max LOD score value.
[d] Max LOD score value. Values between brackets refer to non-significant ($p > 0.05$) QTL detected with CIM.
[e] Phenotypic variability explained by the QTL.
[f] Significance at $p < 0.05$, 0.01 and 0.001 for *, ** and ***, respectively, detected with pooled t-test.
[g] Parental origin of favorable allelic combinations.

Table 5

Chr.	QTL	year	Marker[a]	Sign.[b]	cM[c]	Interval (cM)	LOD[d]	R^2 [e]	Sugar beet (SB) n	Sugar beet (SB) Value	Sugar beet (SB) SD	Table beet (TB) n	Table beet (TB) Value	Table beet (TB) SD	Sign.[f]	Origin[g]
			SMA		CIM				CPA							
I	%SucFW-1	2002	EAGCMCAG220	***	41.2	39.6 - 46.1	4.14	17.8	6	11.6	1.9	18	10.1	1.1	*	SB
	"	2003	EAGCMCAG220	**	41.2	ns	(1.15)	(5.3)	6	11.7	1.7	18	10.5	1.2	ns	-
	%DM/W-1	2002	EAGCMCAG220	*	41.0	ns	(2.70)	(12.9)	6	20.5	2.8	18	18.3	1.8	*	SB
	"	2003	ECATMCAT170	**	42.3	ns	(2.63)	(12.2)	6	19.5	2.0	18	18.0	1.3	ns	-
II	W-1	2002	EACTMCTT228	**	15.3	11.8 – 19.8	4.84	20.8	9	596	126	11	443	114	**	SB
	"	2003	EACTMCTT228	***	15.3	12.3 – 17.5	9.76	40.6	9	836	211	11	465	165	***	SB
	DM-1	2002	ECATMCAT220	*	11.8	ns	(3.22)		8	144	20	11	102	29	**	SB
	"	2003	EACTMCTT228	***	15.3	11.3 – 17.5	7.88	34.3	9	194	47	11	109	32	***	SB
	HSY-1	2002	EACTMCTT228	**	15.3	11.8 - 18.8	5.15	14.4	9	81	15	11	57	16	**	SB
	"	2003	ECATMCAT220	***	12.3	10.9 - 16.1	9.87	47.0	8	121	38	11	64	21	***	SB
	RW-1	2002	EACTMCTT228	**	15.3	11.3 - 18.1	6.54	17.1	9	732	124	11	545	137	**	SB
	"	2003	EACTMCTT228	***	15.3	11.0 -18.1	10.10	43.3	9	1029	261	11	576	159	***	SB
	%SucFW-2	2002	PTCMCAT275	ns	19.3	ns	(2.69)	(17.5)	9	10.9	0.7	12	9.8	1.3	*	SB
	%SucDM-1	2002	PTCMCAT275	*	19.8	ns	(3.01)	(18.5)	9	57.5	4.7	12	55.0	2.9	ns	-
III	HSY-2	2003	PTCMCAT202	*	24.4	19.5 - 28.0	4.44	14.0	9	111	22	10	84	27	*	SB
	%SucFW-3	2003	FDSB1027	**	28.0	27.5 - 29.8	5.39	29.6	17	11.6	1.3	11	10.2	1.2	**	SB
	%DM/W-2	2003	FDSB1027	**	28.0	ns	(2.46)	(12.5)	17	19.5	1.8	11	17.8	1.1	***	SB
	%DM/W-3	2002	PCAMCAG495	*	40.2	ns	(3.07)	(15.4)	18	19.2	1.2	12	17.8	1.3	**	SB
	"	2003	EAGCMCAG506	***	37.7	ns	(3.28)	(15.7)	18	19.7	1.5	12	17.9	1.1	***	SB
IV	%SucFW-4	2002	PCAMACA321	*	61.9	ns	(2.09)	(9.3)	6	11.5	1.5	12	10.1	1.2	ns	-
	"	2003	EACAMCAA133	*	57.1	ns	(0.87)	(4.5)	8	12.1	1.4	12	10.8	1	*	SB
	%DM/W-4	2002	PCAMACA321	**	61.9	ns	(1.33)	(6.8)	6	20.5	2.3	12	18.0	1.4	*	SB
	"	2003	PCAMACA321	**	61.9	ns	(0.78)	(5.8)	6	20.6	1.9	12	18.5	0.9	*	SB
V	%SucDM-2	2003	EACAMACA253	ns	16.0	15.3 - 16.5	6.62	29.6	22	57.9	3.6	7	54.8	4.1	ns	-
	%SucFW-5	2002	PAGMCAT115	ns	19.2	18.6 - 19.3	7.99	27.2	20	11.0	1.4	7	10.8	0.9	ns	-
	%DM/W-5	2002	PAGMCAT115	ns	19.2	18.6 - 19.3	7.07	28.5	20	19.8	1.9	7	19.5	1.5	ns	-
	%DM/W-6	2002	ECAMCAT161	*	29.7	29.2 - 31.3	4.54	26.1	14	19.5	1.6	6	18.7	1.7	ns	-
VI	W-2	2002	ECATMCAT210	**	29.5	27.0 – 29.6	5.45	21.4	7	487	111	7	570	115	ns	-
	"	2003	PAGMAGC183	*	30.2	29.2 – 32.2	4.74	32.8	7	773	237	7	843	186	ns	-
	DM-2	2003	PAGMAGC183	*	31.7	30.2 – 33.3	4.30	32.6	7	178	42	7	204	53	ns	-
VII	%SucFW-6	2003	ECATMCAT290	*	0.5	ns	(2.85)	(25.1)	14	11.6	1	18	10.2	1.1	**	SB
	%SucDM-3	2002	ECATMCAT290	***	0.5	ns	(3.02)	(19.2)	14	18.5	0.9	18	18.5	1.7	ns	-
	"	2003	ECATMCAT290	***	0.5	ns	(2.29)	(16.5)	14	19.0	1.2	18	18.3	1.5	ns	-
	%SucDM-4	2002	BI543691E3	*	19.2	18.9 - 21.2	5.30	29.2	8	56.2	2.3	13	54.5	2.7	ns	-
	"	2003	PACMCAG188	***	18.8	ns	(2.11)	(15.7)	8	58.7	4.1	13	56.2	4.4	ns	-
	DM-3	2002	sbcD203	*	27.9	26.1 – 29.4	4.04	22.9	8	163	42	14	119	31	*	SB
	HSY-3	2002	sbcD203	**	27.9	27.3 - 29.9	4.83	17.1	8	95	25	14	65	18	**	SB
	%SucDM-5	2002	PAGMAGC253	*	30.0	ns	(1.50)	(10.7)	10	57.8	3.8	17	54.5	3.2	*	SB
	"	2003	PAGMAGC253	***	30.0	ns	(2.53)	(20.8)	10	60.5	3.2	17	56.3	4.0	**	SB
	%SucFW-7	2002	FDSB1011	**	32.6	28.9 - 35.1	4.66	25.8	11	11.4	1.4	19	10.2	1.1	*	SB
	RW-2	2002	EACAMCGG300	*	34.5	32.6 - 36.5	4.78	13.9	7	710	209	19	657	154	ns	-
VIII	W-3	2002	PACMCAG120	*	48.2	47.3 – 49.4	4.99	24.0	13	519	65	9	578	107	ns	-
	RW-3	2002	PACMCAG120	*	48.7	47.8 - 49.4	6.14	22.2	13	625	110	9	716	130	ns	-
IX	HSY-4	2003	PCAMCTT273	*	2.9	0.5 - 3.8	5.26	23.1	12	115	38	12	87	27	*	SB
	W-4	2002	9KWS	*	4.7	3.8 – 5.8	5.02	21.0	17	648	112	17	551	114	*	SB
	RW-4	2002	9KWS	*	4.7	3.9- 5.8	4.22	15.0	17	794	136	17	680	141	*	SB
	"	2003	9KWS	*	4.7	ns	(3.06)	(12.2)	15	1032	308	16	830	238	*	SB

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ROOT PLASTICITY TO NUTRITIONAL STRESS IN MEDITERRANEAN SEA BEET

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Abstract: Knowledge of adaptive responses to nutritional stress is required to improve yield stability of sugarbeet. The aim of this research was a comparative study of the root morphological and physiological plasticity among two sea beet populations collected on nutrient poor and rich habitats of the Adriatic coast of Italy and sugarbeet. To evaluate root plasticity, root traits of 12-day-old seedlings grown hydroponically on both complete and incomplete nutrient solutions. After both phosphate and sulfate deprivation, individuals from nutrient-poor habitats displayed the highest increase for total root length and number of root tips than populations from nutrient-rich or cultivated germplasm. The nutrient-poor population also displayed and increase of fine roots (average diameter <0.5 mm) after P- and S-deprivation. These results indicated a higher root plasticity of the plants from -poor than nutrient-rich habitats and, therefore, the former plants might better capture nutrients from low fertility soils. Comparative analysis of response to nutritional stress is a promising approach to identify root adaptive traits to nutritional stress useful for sugarbeet improvement.

Introduction: The study of the root system of plants is attracting growing interest due to the acquisition of new knowledge favoring the identification of adaptive traits determinant to a non-conflicting relationship between crop productivity and environmental conditions (Lynch, 1995). The root system assumes a central role in the regulation of nutrient acquisition from soil because it is inserted in a path of signals that connect it to the assimilation nutrient reaction as well as to the complex chemical, physical and microbiological transformations that take place in the rhizosphere (Passioura, 2002). According to Baluska et al. (2004), the rapid perception of these signals in the apical regions of the root and their conversion to signal molecules (e.g. phytohormones) could depend on the presence, in these regions, of complex and efficient communication networks similar to synaptic regions, responsible for the morpho-functional plastic variations that allow the plant to adapt to the environment. In the root tips of maize, the conversion of exogenous signals (e.g. water stress) into endogenous signals such as hormones (e.g. synthesis of abscisic acid) involved in the regulation of physiological responses, takes place a few minutes after the appearance of stress factors (Itai, 1999). The synthesis of hormones in the root tips seems also to be regulated by translocation to these regions of other molecular signals, like glucose, fructose and fructan (Gibson, 2004). The translocation of soluble carbohydrates in the root tips assumes relevance not only for energetic ends (ATP synthesis) but also in the internal plant processes. In Arabidopsis, the concentration of glucose and fructose in the apical region of the primary root seems to have regulatory functions for the entire root architecture (Freixes et al., 2002).

Recent studies attribute to the root system of the plant a fundamental role in competition for survival in natural environments and in plants, the greater selection pressure occurs for the acquisition of elements of soil fertility (water and nutrients), a characteristic strictly dependent on root morpho-physiology (Rajaniemi et al., 2003). In fact, the diversity of the root system influences the competitive ability of a species in respect to another and therefore the genetic diversity present in the natural environment (Moore, 2003). Smilauerova and Smilauer (2002) have shown that, under nutrient limitation, the greater diffusion in diverse natural sites of *Poa angustifolia* with respect to *Luzula campestris* is related to the higher root development rate and the larger number of lateral roots. Other research carried out in natural environments has shown strict relationships between the dominant plant community and the soil texture. Species characterized by deepened root systems are prevalent in sandy soil with reduced water availability in the surface layers (Dodd and Lauenroth, 1997). Diversity of form and function of the root systems are strictly related to the environment of selection (Gersani et al., 1998). Grime (1994) and Kieron (2003) showed that genotypes subjected to natural selection in nutrient-poor soil were characterized by a superior root-shoot ratio in respect to those coming from sites of elevated fertility.

In the last few years, new and more efficient instruments (software for image analysis minirhizotron, microarray for gene expression analysis, etc.) have become available for root system characterization. Sugar beet may be considered a model plant in this research field, being characterized by a root system that is more developed and deepened in respect to most other cultivated plants (Biancardi et al., 2005). It is believed that sugar beet is derived from sea beet domestication, a wild plant mainly distributed along the Mediterranean coasts. The beets were firstly cultivated for the leaves. The root type (garden beet) appeared during the Roman epoch; in the Middle Ages, varieties utilized for animal feed were selected; and at the end of the 18th Century in Germany, sugar beet was selected for sugar production. The genotypes for sugar were therefore adapted to those environmental conditions characterized by moderate temperatures and well-distributed rains (Biancardi et al., 2005).

The objective faced today is that of improving the level of tolerance to nutritional stress in order to increase the productive stability of sugar beet without high fertilizer inputs (Steinrücken, 2005). It is therefore a priority to identify the new sources of resistance to environmental stress useful for improvement of the cultivated species. It is noted that the genetic variations may also be artificially induced through mutagenesis and genetic transformation of cultivated varieties. Furthermore, these methods currently involve few genetic loci; in the case of genetic transformation, the number of cloned genes available for genetic transfer is minimal. The available raw material remains therefore the wild germplasm and the genetic variants contained within it. Sea beet has been a source of genetic resistance (cercospora and rhizomania) (Biancardi et al., 2002) and possess a noteworthy adaptability that permits it to grown in inhospitable environments characterized by limited water and nutritional availability.

The aim of this work was a comparative study of the plasticity level and genetic divergence of root morpho-physiological traits in two sea beet populations and a sugar beet variety grown both on complete hydroponic solutions, and phosphate and sulfate deprived solutions. The study of the plastic response of the above parameters to nutritional deprivation may allow the identification of root adaptive traits to the nutrient fluctuations that take place in the soil to be transferred in sugar beet.

MATERIALS AND METHODS:

This study was carried out on two sea beet populations (*Beta vulgaris* L. ssp. *maritima*) collected along the Adriatic coast and a sugarbeet variety. The two sea beet populations were collected in different natural sites contrasting for soil fertility. To determine background fertility levels, soil was sampled at the two sites three months before seed sampling. Four soil samples from the surface to a depth of 15 cm and four samples from 15 to 30 cm were collected from random locations within each experiment. The sea beet population collected at Pellestrina growing on a nutrient-rich soil and is here denoted by "SNR", and the population collected at Boccasette growing on a nutrient-poor soil and is termed by "SNP". Seed samples from each sea beet populations were collected at the end of July in two years (2003-2004). Seeds were taken from each of 20 randomly selected individual plants at intervals >2 m between individuals. The geographic distance between population sites was about 70 km. Sugarbeet hybrid Shannon (Lion Seeds) was used for comparison and was denoted as "SB".

Seeds from each entry were surface-sterilized by immersion for 10 min in 1% (v/v) sodium hypochlorite, rinsed several times with distilled water, and imbibed in aerated, deionized water at 22 °C for 12 h. Seeds were transferred to two layers of filter paper moistened with distilled water in Petri dishes placed in a germinator at 25 °C in the dark for 48 h.

Three-day-old seedlings with 10±2 mm long seminal roots, were transplanted on 3 plastic tanks over an aerated solution containing 200 mM $Ca(NO_3)_2$, 200 mM KNO_3, 200 mM $MgSO_4$, 40 mM KH_2PO_4 and microelements, similar to concentrations used by Arnon and Hoagland (1940). The nutrient solution was daily replaced. The tanks were placed in a growth chamber at 25/18°C and 70/90% relative humidity with a 14 h light (60 W m^{-2}) and 10 h dark cycle. On the 6th day, phosphate and sulfate deprivation treatment was started transferring one-half of seedlings on adjacent plastic tanks containing hydroponic solutions where phosphate and sulfate was replaced by the addition respectively of KCl and $MgCl_2$.

Glucose and fructose concentration were determined on apical (0.5 mm long) regions of primary roots harvested at the beginning of the photoperiod 6 d after replanting to the different growth conditions. Each sample was rapidly rinsed in water then placed in 0.2 ml 80% ethanol at 80 °C for 15 min. Extraction was repeated and the two extracts were pooled. The solution was then dried under vacuum (SC110A; Savant Instruments Inc., Farmingdale, NY, USA). The extracts were re-suspended in 0.15 ml of distilled water and the soluble carbohydrates (glucose and fructose) were quantified using a Technicon Instruments AutoAnalyzer (Pulse Instrumentation, 1992, Canada) using standard procedures. Glucose and fructose concentration were quantified using calibration curves.

Primary root length of individual seedlings was manually measured every day using a plastic ruler after initiation of nutritional stress until seedlings were 12 days old. The primary root elongation rate was calculated for each day from the difference in root length between two different measurements on different days. Root morphological traits were evaluated on the 12-day old seedlings by means of a scanner-based image analysis system (WINRHIZO Pro, Regent Instruments, Quebec, Canada) that controls scanning, digitizing and analysis of root samples. Before taking measurements, the entire root

systems of individual plants were stained for 15 min with 0.1% (w/w) of toluidine blue (Sigma-Aldrich, Montréal, Quebec) to increase contrast and washed free of stain with deionized water. The stained individual root systems were floated in 3 mm of water in a 0.3 x 0.2 m Plexiglas tray, and all lateral roots were spread with a plastic spatula, to minimize root overlap. The tray was placed on the glass surface of a STD-1600 EPSON scanner set to a scanning resolution of 1200 dpi. The images were used to determine the total root length (cm), the number of root tips, and the average root diameter (cm). The image analysis system allows the classification of roots into ranges of root diameter. In this study, we used 3 diameter ranges from 0.0 to 1.5 mm in 0.5 increments.

Data were subjected to ANOVA using the Statistica software (Statsoft, Tulsa, OK, USA) to calculate the significance of different factors. Least Significant Difference test (LSD) at the 0.05 probability level was used to compare data from different factors. Phenotypic plasticity was determined for each root trait by measuring the percentage variation of the trait observed after phosphate deprivation (-P) and sulfate deprivation (-S) compared to complete nutrient (+), according to the formula adapted from Zhu et al. (2005): 100 x (root measure under nutritional deprivation – root measure under steady condition) / root measure under steady condition.

RESULTS AND DISCUSSION:

At steady nutrient supply, variation among the three entries was significant ($P < 0.01$) for all root morpho-physiological traits (Table 1). The cultivated variety (SB) showed the highest glucose and fructose concentration in the root tips, primary root elongation rate, total root length and number of root tips. As described by Freixes et al. (2002), increasing glucose and fructose concentration in the root tips has been shown to promote the elongation of the primary root. Significant differences ($P < 0.01$) among the three entries were also observed after both P- and S-starvation (Table 1). The highest glucose concentration in the root tips, root elongation rate, total root length and number of root tips was observed in the cultivated variety after nutritional limitation. The root adaptive strategy to nutritional stress of the domesticated plants mainly favors an increase in glucose and fructose concentration in the root tips on which the growth of the primary root depends (Table 2). The cultivated variety displayed the lowest increase for root morphological traits, such as total root length and root tips, after nutritional deprivation. The low plasticity for these traits likely relates to soil exploration and nutrient acquisition and may explain the low productivity of the cultivated variety in low fertility soils (M. De Biaggi, 2005, personal communication).

The sea beet nutrient-rich population (SNR) is characterized by medium root morpho-physiological plasticity for all traits examined, whereas that of the nutrient-poor population (SNP) showed lower plasticity for glucose and fructose concentration and primary root elongation rate but the highest plasticity for total root length and number of root tips after P- and S-starvation (Table 2). The nutrient-poor population also displayed the highest increase of the extremely fine roots (<0.5 mm) after P- and S-starvation (Table 3). Plasticity for fine roots production is a trait of interest because it may be related to the ability to maximize nutrient acquisition from nutrient-enriched micro sites along the soil profile.

Previous research highlighted a wide genetic diversity amongst sea beet populations on the Adriatic coasts, between them and cultivated sugarbeet (Bartsch et al., 2002). The diversity and genetic divergence found were related to variation in root architecture (morphological plasticity) and possibly of differentiation of efficient transport systems in order to accommodate variation in nutrient concentration (physiological plasticity).

These results demonstrate that different levels of soil fertility affect root morpho-physiological plasticity of these two sea beet populations. The selective pressure that distinguishes the less fertile environment may have promoted the selection of a sea beet population with high root morpho-physiological plasticity to allow more adaptation to nutrient availability fluctuations in the soil. The plasticity of root system may be related not only to soil conditions but also to competition with other plant species. In fact, below ground competitive ability is strictly correlated with plasticity in morphological and physiological traits involved in nutrient uptake (Casper and Jackson 1997).

The considerable plasticity to nutritional stress of the nutrient poor population might be also linked with its ability to adapt its root systems to soil conditions by means of an enhanced interplay among nutrient, sugar and hormone signaling systems. Further studies could help understand mechanisms underlying the highest plasticity of the nutrient poor population and its eco-physiological significance. As a next step, a genomic approach will be used to study after nutritional deprivation the changes in the transcript levels of many genes involved in the nutrient assimilation, sucrose metabolism and hormone synthesis.

In conclusion, it appears that the sea beet of the Adriatic coast of Italy is a source of genetic resistance to adverse environmental stress. The knowledge gained from this investigation might lead not only to a better understanding of root morpho-physiological traits involved in the ecological tolerance of individuals, but also to the identification of genetic markers useful for efficient selection in the development of sugar beet genotypes for nutrient-limited conditions.

Table 1: Glucose and fructose content in the root apical region, root elongation rate, total root length, number of root tips of three entries grown in complete(+), under phosphate deprivation (-P) and sulfate deprivation (-S) nutrient solutions. Values are also expressed as a percentage of the control (SB). Values followed by different letters are significantly different at LSD = 0.05.

Entry	Treatment	Glucose and fructose content		Root elongation rate		Total root length total		Number of root tips	
		μm mm^{-3}	*%*	*mm day^{-1}*	*%*	*cm*	*%*		*%*
SB	+	1.5 a	100	9.0 a	100	20.6 a	100	29 a	100
SNR	+	1.2 b	80	5.4 b	60	10.3 b	50	11 b	38
SNP	+	1.0 c	67	5.2 b	58	7.7 c	37	8 c	28
SB	-P	1.6 a	100	8.7 a	100	21.0 a	100	34 a	100
SNR	-P	1.2 b	75	5.4 b	62	11.1 b	53	14 b	41
SNP	-P	1.0 c	63	5.2 b	60	8.7 c	41	12 b	35
SB	-S	2.2 a	100	12.6 a	100	22.0 a	100	30 a	100
SNR	-S	1.5 b	68	7.3 b	58	15.0 b	68	16 b	52
SNP	-S	1.2 c	55	6.2 b	49	12.8 c	58	20 c	66

Table 2: Percent variation of root traits measured after phosphate deprivation (-P) or sulfate deprivation (-S) compared with a steady nutrient supply.

Entry	Treatment	Glucose and fructose content	Root elongation rate	Total root length	Number of root tips
		percent			
SB	-P	7 ns	-3 ns	2 ns	17 *
SNR	-P	0	0	8 ns	27 **
SNP	-P	0	0	13 *	46 **
SB	-S	47 **	40 **	7 ns	5 ns
SNR	-S	25 **	35 **	46 **	45 **
SNP	-S	20 **	19 *	66 **	144 **

*Statistical significance: * P < 0.05   ** P < 0.01   ns = not significant*

Table 3: Percent variation in the distribution of total root length (cm) among diameter ranges (D) examined after phosphate deprivation (-P) and sulfate deprivation (-S) compared with a steady nutrient supply.

Entry	Treatment	Total root length (cm) 0.0 < D < 0.5	0.5 < D < 1.0	1.0 < D < 1.5
		percent		
SB	-P	+13% *	-26% **	+6% ns
SNR	-P	+19% *	-18% *	0
SNP	-P	+31% **	-14% *	+7% ns
SB	-S	+34% **	-59% **	+3% ns
SNR	-S	+88% **	-49% **	+5% ns
SNP	-S	+147% **	-47% **	+5% ns

*Statistical significance: * P < 0.05   ** P < 0.01   ns = not significant*

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GENOME-WIDE EXPRESSION RESPONSES TO NUTRITIONAL STRESS IN MEDITERRANEAN SEA BEET

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The sea beet (*Beta vulgaris* L. ssp. *maritima*) is of great interest as source of genetic resistances to adverse environmental conditions useful for the enhancement of sugar beet. In the past, genetic resistances to cercospora leaf spot and rhizomania have been transferred from sea beet to sugar beet (Biancardi et al. 2002) and, in recent years, the gene pool of sea beet is also a source of resistance to abiotic stress (Luterbacher and Smith 1998).

Sea beet is common along Mediterranean coasts, and its adaptability allows it to growth even in nutrient-poor or salty soils (Stevanato et al. 2001; Bartsch et al. 2002). Mapping the distribution of natural sea beet populations along the Adriatic coast has been recently completed. Representative samples of seed were collected from each population to study traits with potential important roles in the ecological tolerance of individuals. Previous results have shown that some sea beet populations collected on poor- and rich-nutrient soils differ in their root morpho-physiological responses to nutritional stress (Stevanato et al. 2005). These results indicated a superior root plasticity of the plants from poor- than nutrient-rich habitats that allows them to face the wide fluctuations of nutrient concentration that take place in the rhizosphere and, therefore, a better adaptation to nutritional stress.

Phosphorous (P) is often cited one of the most limiting macronutrient for plant growth and crop productivity (Marschner 1995). Several studies have focused on the plastic changes in plant root architecture to maximize the efficiency of phosphorus acquisition (Hodge 2005). Only few studies have investigated, by a wide-scale gene expression analysis (e.g., cDNA-AFLP and microarray technologies), the complex molecular mechanisms underlying root system responses to nutritional stress. In addition, the study of genes regulating these responses is often only based on mutants as *Arabidopsis thaliana* (Chevalier et al., 2003).

The identification of the genetic traits underlying the response to nutritional stress in sea beet may be useful in sugar beet breeding for multiple traits, which include yield stability. Here, we report preliminary results of a study aimed to compare, by cDNA-AFLP analysis, the patterns of gene expression responses to phosphate deprivation of a sea beet population collected on nutrient-poor soil and a sugar beet commercial variety.

MATERIALS AND METHODS:

The sea beet population included in this study was collected on August 1, 2005, at Boccasette (Rovigo, Italy; N 45° 02’, E 12° 21’). The collection site was very nutrient-poor. The commercial sugar beet variety “Shannon” was supplied by Lion Seeds (UK).

To synchronize the time of germination between the sea beet population and the cultivated variety, seeds were treated with a 0.3% H_2O_2 aqueous solution for 48 h (McGrath et al., 2000). Germinated seedlings with 10±2 mm long seminal roots, were transplanted in plastic tanks on an aerated solution containing 200 mM $Ca(NO_3)_2$, 200 mM KNO_3, 200 mM $MgSO_4$, 40 mM KH_2PO_4 and microelements (similar to Arnon and Hoagland, 1940). Phosphate-depleted seedlings were obtained by replacing phosphate with KCl on the 6th day.

Samples of roots of twelve-day old seedlings will be collected and snap-frozen in liquid nitrogen. Total RNA was isolated from root samples using the Qiagen RNeasy Plant RNA purification kit (Qiagen, Hilden, Germany). Double stranded cDNA was synthesized with the SMART cDNA Synthesis kit (Clontech, Palo Alto, CA, USA).

cDNA-AFLP procedures were based on the methods described in Bachem et al. (1996) and Trebbi and McGrath (2003) with some modifications. Double stranded cDNA was digested with *Mse*I and *Taq*I restriction enzymes (New England BioLabs, Beverly, MA). The digested DNA was ligated to *Mse*I and *Taq*1 adaptors to generate DNA templates for amplification. For pre-amplification, a non-selective *Mse*I (M+0) primer was combined with non-selective *Taq*I (T+0) primers. cDNA-amplified fragments were purified using a MinElute PCR Purification Kit (Qiagen, Hilden, Germany).

IRD700 and IRD800 fluorophore-labeled *Taq*I primers each containing two selective nucleotides (IRD+2) (MWG-Biotech, Ebersberg, Germany), and an unlabeled *Mse*I primer with two selective nucleotides (M+2) were used for selective amplifications. Fifteen different primer combinations were adopted in selective amplification (Table 1).

Table 1: List of adapter and primer sequences used for cDNA-AFLP analysis.

Adapters and primers	Sequences
*Mse*I adapter top strand	5'- TACTCAGGACTCATC - 3'
*Mse*I adaptor bottom strand	5'- GACGATGAGTCCTGAG - 3'
*Taq*I adapter top strand	5'- AGAGATGAGTCCTGA - 3'
*Taq*I adapter bottom strand	5'- CGTCAGGACTCATC - 3'
*Mse*I primer (non selective amplification)	5'- GATGAGTCCTGAGTAA - 3'
*Taq*I primer (non selective amplification)	5'- GATGAGTCCTGACGA - 3'
*Mse*I primer (selective amplification)	5'- GATGAGTCCTGAGTAAX - 3' (X is AC, AG, CA, GA, GT)
*Taq*I primer (selective amplification)	5'- GATGAGTCCTGACGAX - 3' (X is CA, GA, GT)

Fragments were separated on 7% poly-acrylamide gels using LI-COR 4200 Automated DNA Sequencer. Gel images were collected, saved as image files and TDFs (transcript derived fragments) were scored to obtain binary datasets of polymorphic expression (band presence/absence).

RESULTS AND DISCUSSION:

cDNA-AFLP transcript profiling allows qualitative mid - to large-scale gene expression analyses, and it requires very low amounts of starting material without prior knowledge of target gene sequences (Breyne and Zabeau 2001). This technique was used to evaluate the differential gene expression in response to phosphorus deprivation in roots of wild and cultivated beet subspecies. Observed DNA fragments on polyacrylamide gels ranged in length from 80 - 650 bp, with the majority of fragments sized from 120 - 300 bp. Ca. 370 TDFs were scored using 15 primer combinations, with an average of 24 TDFs displayed for each primer combination.

Profiles of gene expression between germplasms grown in complete nutrient and under phosphorous stress were quite dissimilar. Up to 14% of the fragments were differentially expressed after phosphorous deprivation. These differentially expressed TDFs between control plants and nutrient-stressed plants may be directly involved in mechanisms of response to phosphorous deprivation. cDNA-AFLP profiles displayed considerable differences in the expression of several genes between wild and cultivated subspecies. Up to 46% of the TDFs were differentially expressed in the sea beet versus cultivated beet. Therefore, cDNA-AFLP profiles can identify specific polymorphic expression patterns that differentiate among *Beta* subspecies.

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EXISTENCE OF RESISTANCE GENE ANALOGUES IN SUGAR BEET AND RELATED GERMPLASM

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Abstract: Host-plant disease resistance is a useful characteristic in sugar beet breeding. Plant *R* (resistance) genes confer resistance to a variety of pathogens through a yet unclear mechanism. Conserved *R* gene motifs have been exploited to identify 47 resistance gene analogues (RGAs) in sugar beet, for which primers have been designed. Using a PCR approach, these RGAs were tested for presence in genomic DNA of related germplasm and a range of cDNA libraries representing various tissue types and environmental conditions. All of the studied RGAs were found to be present in the genomic DNA of at least two of the studied germplasms and expressed in at least two of the studied cDNA libraries. This exploratory experiment confirms the usefulness of the set of sugar beet specific RGA primers in studying other varieties of sugar beet and cultivars of *Beta vulgaris*. Variation noted may constitute useful genetic variation in breeding programs.

Introduction: Sucrose has been an important part of the human diet for thousands of years. Other than the sugar cane, the sugar beet (*Beta vulgaris*) is the only other major source of sucrose, comprising more than a third of the world's sucrose supply. It is complementary to cane sugar since it grows in temperate regions where sugar cane cannot (Cooke & Scott 1993). Sugar beet and all other domesticated beets are descendants of the wild beet (*Beta vulgaris* ssp. *maritima*), also known as the sea beet. It is believed that leaves of wild beet were used by man as a vegetable since prehistoric times, and that it was first domesticated around 5,000 years ago. For most of history, beet varieties were grown mainly for leaf production (Biancardi 2005). Sugar shortages during the Napoleonic wars of the early 19th century generated interest in use of the beet plant as a source of sugar, and ultimately resulted in its successful cultivation (Ballinger 1975). It is now recognized as the first plant to be bred entirely based on an understanding of modern genetics (Biancardi et al. 2005). Due to its narrow germplasm base, derived from one type of fodder beet, sugar beet is particularly vulnerable to diseases (Lewellen 2004), including curly top, rhizomania, *Rhizoctonia* root rot and seedling blight, *Cercospora* leaf spot, and pathogenic bacteria and nematodes (Hunger et al. 2003). One disease of particular interest is crown and root rot and seedling damping off caused by the soil-borne fungus *Rhizoctonia solani*, which can kill the plant or reduce root and sugar yield by 50% or more. Disease reduces the economic value and increases processing costs of the crop (Büttner et al. 2003). One major factor of the success of sugar beet has been the ability of science to control pathogens destructive to them (Duffus and Ruppel 1993). Developing host plant resistance to disease is currently an active research topic. This technique has met some success, as in sugar beet resistance to curly top and rhizomania. However, some types of resistance have not been discovered or are incomplete, and may be accompanied by undesirable characteristics such as reduced yield (Biancardi 2005).

Plant disease resistance is generally attributed to a wide class of disease resistance (*R*) genes, which confer host plant resistance to a variety of plant pathogens. The mechanism of plant disease resistance is not completely understood. In the traditional model, *R* genes putatively encode proteins that detect pathogen avirulence gene (*Avr*) products, activating signal pathways that ultimately result in a defense response. The more recent guard hypothesis suggests that *R* proteins respond to pathogen interactions with another plant protein, hence "guarding" the "guardee" targeted by the pathogen (McDowell & Woffenden 2003). Significant efforts in the last decade have led to the identification of many functional *R* genes encoding resistance to a wide variety of diseases (Dangl & Jones 2001). Their identification can eventually help to identify linked genes involved in disease resistance because resistance genes often occur in clusters (Hunger et al. 2003).

R genes of many plant species share conserved domains, regardless of the pathogen involved. These conserved protein domains are sufficient to identify conserved regions of DNA using PCR amplification with degenerate primers. By using this approach, 47 resistance gene analogues (RGAs) in sugar beet populations 618 and K2 have been identified, of which 33 have been mapped (Hunger et al. 2003). RGAs potentially encode proteins responsible for disease resistance characteristics. There has not yet been published research on the existence of these RGAs in related varieties, cultivars, and species of sugar beet.

The purpose of this research was to use a PCR approach to screen for the existence of RGAs that have been found in sugar beet (Hunger et al. 2003) in a variety of genomic DNA and cDNA samples. In the first phase of experiment, genomic DNA of closely related varieties such as red beet (*Beta vulgaris*), wild beet (*B. vulgaris* spp. *maritima*), Swiss Chard (*B. vulgaris* L. var. *flavescens*), as well as in a more distant species such as spinach (*Spinacia oleracea*) was studied. Three varieties of sugar beet were tested: USH20, EL51, and C869. USH20 is a variety with moderate gross sugar yield, and possesses moderate resistance to *Cercospora* leaf spot, black root disease, and beet curly top virus (BCTV) (Coe & Hogaboam 1971). EL51 is resistant to infection by *Rhizoctonia solani* (Halloin et al. 2000), while USH20 is susceptible (Nagendran & McGrath 2004). C869 is a recently released germplasm exhibiting resistance to rhizomania and BCTV (Lewellen 2004). cDNA libraries representing tissue of stress germinated seedlings, leaf, inflorescence, developmental root, 10-week old root, and 1 month cold storage root was tested in the second phase of the experiment.

The identification of differences in RGAs among *B. vulgaris* and *B. maritima* varieties helps in understanding disease resistance mechanisms in sugar beet, as well as the eventual identification of *R* genes, of which some will be a subset of the RGAs. There have been continued efforts to incorporate the disease resistant characteristics of wild relatives into commercial sugar beet germplasm, but because wild varieties carry many undesirable characteristics, this is a long-term program requiring many selection cycles (Doney 1996). New genomic technologies can bring useful alleles from the wild germplasm into sugar beet more efficiently (McGrath 2005). Varieties high in sucrose production may be crossed with varieties possessing known functional *R* genes to produce new lines with high sucrose production and better resistance to disease.

HYPOTHESES TESTED:

1. Most of the RGA's identified by Hunger et al. (2003) will be present in other *B. vulgaris*, but some will exist only in certain cultivars. More distantly related germplasm will possess differences in RGAs. Differences discovered may represent useful genetic variation for disease resistance breeding.
2. cDNA libraries will exhibit variation in amplification due to expression differences in tissue type and under distinct environmental conditions. Differences may relate to the specificity of RGA expression. Libraries representing stressed conditions such as the stress germinated seedling library may show more RGA expression due to similarities to pathogen-induced stresses.

MATERIALS AND METHODS:

Genomic DNA of USH20, EL51, C869, Swiss chard, red beet, wild beet, and spinach was used. DNA of EL51 and spinach was extracted using the QIAGEN DNeasy Plant Mini kit, following the manufacturer's protocol. Seed was germinated by soaking in 0.3% hydrogen peroxide for 24 hours at room temperature, followed by water germination for 48 hours in order to accelerate and synchronize germination. Seeds were planted in "Baccto" high porosity soil and watered daily. Primary leaves were collected after 10 days. Fresh spinach leaves were purchase at the local market.

cDNA libraries of stress germinated seedlings, leaf, developmental, 10-week old root, inflorescence, and 1 month cold storage sugar beet tissue were also provided by the Sugarbeet and Bean Research Unit. DNAs were screened for RGAs using PCR using specific RGA primers published by Hunger et al. (2003). PCR was performed in a total volume of 20 μL containing 0.2 mM dNTPs, 2.5 mM MgCl2, 0.375 μM of each primer, 0.1 U of Taq DNA polymerase, and 25 ng of DNA sample in 1x Thermophilic DNA Polymerase Buffer, Magnesium Free consisting of 10 mM Tris-HCl (pH 9.0 at 25°C), 50 mM KCl and 0.1% Triton® X-100 (Promega Part# M190A, M190G). PCR was be performed using an initial denaturation for 90 s at 94°C; 12 cycles of 30 s at 94°C, 30 s at 58°C decreasing 0.8°C each cycle, and 60 s at 72°C; 25 cycles of 30 s at 94°C, 30 s at 47°C, and 60 s at 72°C; followed by a final extension step for 10 min at 72°C. PCR products were run through agarose gels consisting of 2 g agarose and 1 μL ethidium bromide per 100 mL 1x TAE buffer consisting of 0.482 g Tris, 0.0675 g sodium acetate, and 0.0375 g Na_2EDTA per 100 mL, adjusted to pH of 7.6 with acetic acid. Gels were observed under UV light for the presence or absence of each RGA gene.

RESULTS AND DISCUSSION:

PCR was performed on the genomic DNA and cDNA libraries using each of the 47 primers. Results were tabulated in Table 1.

Genomic analysis: The majority of RGA were found in the six studied *B. vulgaris* varieties, suggesting that the sugar beet specific primers can be used on other germplasm to screen for RGAs using a PCR approach. The primers are relatively specific, since most produced a single band in amplification. The diminishing effectiveness of the primers in

other species is apparent; only 11 of the 47 primers amplified genes in spinach. This supports the hypothesis that similarity decreases with increasing phylogenetic distance. Seven RGAs were present in all studied germplasms, suggesting that they are highly conserved. Nineteen were found to be present in all *B. vulgaris* but not spinach. The remaining 21 RGAs exhibited variation across germplasms. Surprisingly, only one RGA was specific to sugar beet. Results were analyzed considering location on linkage map and NBS/LRR/kinase similarity. No relationship between location, region of similarity, and RGA presence were discovered. Interestingly, of the 33 mapped RGAs, all exhibiting multiple amplifications, contained an LRR similarity. This finding may suggest that RGAs containing LRR similarities are more likely to exhibit length polymorphisms.

RGA expression analysis: Forty-six RGAs were present in USH20 genomic DNA. Interestingly, AD1, the only RGA absent in USH20 genomic DNA, was found expressed in the cDNA libraries. This gene may have been absent from the USH20 pool from which the genomic DNA extracted. All RGAs were expressed in at least two of the studied cDNA libraries, confirming that these are genes are expressed in sugar beet. Only EI1 was expressed in all cDNA libraries; all others varied in expression. Most RGAs were expressed in the stress-germinated seedlings, leaf, cold storage, and developmental libraries, while only 22 and 24 were expressed in the 10-week root and the flowering libraries. Only five RGAs were specific to root tissue, and none were specific to other tissue types. The stress germinated seedling library expressed 38 of the RGAs; however, the hypothesis that stressed plants will show more RGA expression is inconclusive since the leaf, developmental, and cold storage libraries exhibited similar levels of expression. Analysis of RGA expression based on region similarity and linkage map location revealed no relationships.

Conclusion: RGAs identified from 618 and K2 populations of sugar beet are present in other *B. vulgaris* and expressed in most tissue types under a variety of environmental conditions. A PCR approach is sufficient to screen for the presence of most of the RGAs. However, since the presence and expression of these RGAs appeared to be independent, future analysis on a case-by-case basis would likely be most effective.

			Region of similarity in linkage map			Mapped location		Genomic DNA							cDNA libraries						
RGA	Genbank Accession Number	Region of similarity	NBS	LRR	kinase	Linkage group	cM	USH20	EL51	C869	Swiss chard	Red beet	Wild beet	Spinach	Genomic	10 week	Leaf	Flower	Cold storage 1 month	Developmental	Stress germinated
EI1	BH897904		1	0	0	7	22	1	1	1	1	1	1	0	2	2	1	2	2	2	2
EI4	BH897905							1	1	1	1	1	1	0	1	1	1	1	0	1	1
EI20	BH897906		1	0	0	5	15	1	1	1	1	1	1	0	1	0	0	0	1	1	1
EI26	BH897907		1	1	0	9	30	1	1	1	0	0	1	0	1	0	0	0	0	1	1
Y3	BH897908		1	1	0	3	40	1	1	1	1	1	1	0	1	0	1	0	1	2	1
Y5	BH897909							1	1	1	1	1	0	0	2	2	2	0	1	2	2
AB4	BH897910		1	0	0	9	35	1	1	1	1	1	1	1	1	0	1	0	1	1	1
AD1	BH897911		1	0	0	3	47	0	1	1	0	0	1	0	0	1	0	1	0	0	1
AD2	BH897912							1	1	1	0	0	0	0	1	2	0	2	0	1	0
AD10	BH897913							1	1	1	1	1	1	0	1	0	1	0	1	1	1
AE4	BH897914							2	2	2	2	0	2	2	2	2	2	2	2	1	1
10A20	BU089547	PK	0	0	1	6	28	1	1	1	1	1	0	1	1	1	1	1	1	1	1
1D17	BU089548	PK	0	0	1	5	19	1	1	1	1	1	1	0	2	0	0	1	0	1	1
1O14	BU089549	PK	0	1	0	9	22	1	1	0	1	1	1	0	1	2	2	1	2	2	0
4L18	BU089550	PK	0	0	1	1	59	1	1	1	1	1	1	0	2	0	0	0	1	1	1
5D23	BU089551	PK	0	0	1	4	10	1	1	1	1	1	1	1	1	0	1	1	1	1	1
7A24	BU089552	PK	0	0	1	3	45	1	1	1	1	1	1	0	1	0	1	1	1	1	1
7L01	BU089553	PK						1	0	0	1	0	0	0	2	0	1	1	1	1	1
9G24	BU089554	PK	0	0	1	3	32	1	1	0	1	0	0	0	2	1	0	0	1	0	0
1F09	BU089555	DRR	0	0	0	9	29	1	1	1	1	1	1	1	1	2	2	1	2	2	0
4P09	BU089556	-						2	2	2	2	2	2	0	2	2	1	0	0	1	1
3E14	BU089557	PK						2	2	2	1	2	1	1	2	0	2	2	1	2	2
4M07	BU089558	TM-PK	0	0	1	8	10	1	1	1	1	1	1	0	1	0	1	1	1	1	1
1L14	BU089559	TM-PK	0	1	0	7	0	1	0	1	1	1	1	0	2	2	1	0	0	0	1
9J14	BU089560	LRR-TM-PK	0	1	1	6	18	1	1	0	1	1	1	1	2	1	1	0	1	1	1
7M20	BU089561	LRR-TM-PK	0	1	1	7	14	1	1	1	1	1	1	2	1	0	0	0	0	1	1
7H14	BU089562	LRR-TM-PK						1	1	1	1	1	1	0	2	0	1	0	1	1	1
7B17	BU089563	LRR-TM-PK	0	1	1	8	10	1	0	1	1	2	2	2	1	0	1	1	1	1	1
6L04	BU089564	LRR-TM-PK	0	1	1	7	22	1	1	0	1	0	0	0	2	0	2	2	2	2	2
4F03	BU089565	LRR-TM-PK	0	1	1	5	0	1	1	2	1	1	1	0	2	0	1	0	2	1	2
1D12	BU089566 /BU089567	LRR, PK	0	1	1	7	17	2	2	2	2	0	2	0	2	2	2	1	2	1	0
8C05	BU089568	LRR	0	0	1	6	0	1	0	0	0	0	1	0	2	2	1	0	0	1	1
5E07	BU089569	LRR						1	1	1	1	0	0	0	1	0	1	0	1	1	1
5C15	BU089570	LRR						2	2	2	2	2	2	0	2	0	2	2	2	1	2
2M02	BU089571	LRR-TM	0	1	0	4	51	1	1	1	1	1	1	0	1	0	1	1	1	1	1
8M01	BU089572	LRR	0	1	0	7	22	1	1	1	1	1	1	0	1	0	1	0	1	1	1
8H04	BU089573	LRR	0	1	0	5	18	2	2	2	2	1	1	0	2	2	2	1	0	1	1
2D06	BU089574	LRR	0	1	0	2	22	1	2	2	1	1	1	1	2	2	1	0	0	0	1
7M11	BU089575	NBS	1	0	0	7	23	1	1	0	1	1	1	0	1	0	1	1	1	1	1
2G14	BU089576	NBS	1	0	0	7	23	1	1	1	1	1	1	0	1	0	1	1	1	1	1
EI-7C-01	BU089577		1	0	0	7	22	1	1	1	1	0	1	0	1	0	1	0	1	1	1
AD-c-15c	BU089578		1	0	0	2	62	1	1	1	1	1	1	0	2	0	2	1	2	1	2
AD-c-01c	BU089579		1	0	0	7	37	1	1	0	1	1	1	0	2	2	1	0	1	2	0
AD-c-11c	BU089580							2	2	2	1	1	1	1	1	1	0	0	0	1	0
AD-c-08c	BU089581							1	1	1	1	1	1	0	2	2	1	0	2	1	1
AD-c-16c	BU089582							1	1	1	0	1	1	0	2	2	2	0	2	2	0
AD-c-12b	BU089583		1	0	0	6	17	1	0	1	0	0	0	0	2	2	2	1	2	1	0

Table 1: RGAs in 7 genomic DNA samples and 6 cDNA libraries. KEY: 0 = no amplification, 1 = single band, 2 = multiple bands

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NOTICE OF RELEASE OF EL53 SUGARBEET GERMPLASM WITH SMOOTH-ROOT AND IMPROVED RESISTANCE TO RHIZOCTONIA CROWN AND ROOT ROT

The Agricultural Research Service of the U. S. Department of Agriculture and the Beet Sugar Development Foundation announce the joint release of EL53 sugarbeet germplasm substantially derived from previously released smooth-rooted, low soil tare germplasm releases with two cycles of selection for freedom from crown and root rot disease caused by *Rhizoctonia solani* Kühn (AG2-2). Previous low soil tare releases have been uniformly susceptible to Rhizoctonia crown and root rot, and the moderately resistant germplasm EL52 was used as a source of resistance during the development of EL53. EL53 was developed at the USDA-ARS Sugarbeet and Bean Research Unit, East Lansing, Michigan by J.M. McGrath. EL53 has shown good agronomic performance, and it is expected to be a resource for developing low soil tare parental lines for hybrid cultivars with economically recoverable levels of sucrose.

EL53 is diploid self-sterile with predominantly red hypocotyls (>80% red), and segregates for monogerm seed type as well as the smooth-root trait. EL53 has a complex pedigree involving seven previously released smooth-root germplasm lines, two unreleased smooth-root breeding populations, and three traditional East Lansing germplasm releases. Most (59%) of EL53's parentage stems from smooth rooted materials. Specifically, contributors and their proportional contribution to EL53 are as follows: SR80 (PI 607898), 6%; SR87 (PI 607899), 12%; SR94 (PI 598076), 6%; SR95 (PI 603947), 3%; SR96 (PI 628272), 3%; SR97 (PI 628273), 3%; EL0204 (PI 632750), 9%; EL50 (PI 598073), 9%; EL52 (PI 628274), 15%, and USH20 (PI 631354), 18%. Two breeding populations were also used; 99J19-00 (3%) and 99J31-00 (12%). These two breeding populations were derived from mother roots simultaneously selected at East Lansing over two cycles for smooth-root and Rhizoctonia crown and root rot resistance, originating from separate F_2 populations of crosses between 95H07 and 85B1-R25, respectively.

EL53 was selected solely under conditions promoting development of Rhizoctonia crown and root rot in the East Lansing disease nurseries in 2001 (Test 01EL31) and 2002 (Test 02EL43). In 2001, 33 roots were selected in the proportions indicated above, randomly inter-pollinated in the greenhouse, and seed harvested from individual plants. The 33 roots were selected from within a four-fold replicated completely randomized block with 14 entries. The average stand count 30 days after inoculation with millet-infested *Rhizoctonia solani* AG2-2 was 8.8 plants per plot (Root Mean Square Error = 6.0). Thus, the selection intensity was ca. 6.25% of plants surviving after inoculation. This seed increase was designated 01B024. In 2002, seed from each individual plant harvest was planted to a single 24-foot long row, and selections were taken from 26 of the original 33 progeny lines evaluated for resistance in the 2002 Rhizoctonia nursery. Seventy-six roots were selected solely on freedom of crown and root rot symptoms, and randomly divided into two groups of 38 roots each. The final stand at harvest and selection was 332 plants, thus the selection pressure was 23% of surviving plants. The first group of 38 roots was intercrossed in the 2003 greenhouse, designated 02B094, and this seed was increased at the West Coast Beet Seed, Co. in Salem, OR (designated WC040022). The other 38 roots were randomly inter-pollinated in a plot in St. Johns, MI during the summer of 2003, and this seed was designated 03B017. EL53 has been tested as 01B024, 02B094, and 03B017.

EL53 is moderately resistant to Rhizoctonia crown and root rot, Cercospora leaf spot, and Aphanomyces diseases as evaluated over two years (2005 only for Aphanomyces) in the USDA-ARS, Ft. Collins and Betaseed, Shakopee, MN disease nurseries in 2004 and 2005. In all cases, EL53 was more susceptible, but not significantly different from, the moderately resistant check, or in the case of the Aphanomyces nursery where the resistant check was not scored, EL53 was better but not significantly different from the moderately susceptible check, in each year considered separately.

EL53 was evaluated for agronomic performance at the Saginaw Valley Bean and Beet Farm (Saginaw, MI) in 2003, 2004, and 2005. Over all, EL53 showed 91% of the sugar content (16.1% vs. 18.1%), 105% of the harvested root yield (21.9 vs. 20.9 tons per acre), and 92% of the sugar yield per acre (6509 vs. 7080 lbs. sucrose) of the check varieties E17 and B5736, averaged over the three years. EL53 has excellent emergence and stand persistence.

EL53 is being released as a germplasm source for breeders to use in developing parental lines combining smoothrootedness with higher levels of Rhizoctonia crown and root rot resistance than is currently available in smooth-root material. EL53 also contains a series of useful characters at low allele frequencies derived from EL53's components, such as those necessary to breed for seed parents used to create cytoplasmic male sterility-mediated hybrids as well as the *Rz*1 source of rhizomania resistance. Seed will be available for use by writing to Dr. J. Mitchell McGrath, USDA-ARS, 494 PSSB, Michigan State University, East Lansing, MI 48824-1325. Efforts of Drs. L. Hanson and L. Panella of the USDA-ARS, J. Miller and M. Rekoske of Betaseed, Inc., and T. Duckert and T. Koppin at East Lansing in providing valuable disease nursery and agronomic testing assistance is gratefully acknowledged. Genetic material of this release has been deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new cultivars. It is requested that the author be notified if this germplasm contributes to the development of a new breeding line or cultivar.

NOTICE OF RELEASE OF TBEL1 TABLE BEET GERMPLASM WITH HIGH SWEETNESS AND CYLINDRICAL SHAPE

The Agricultural Research Service of the U. S. Department of Agriculture and Michigan State University jointly announce the release of TBEL1, a table beet germplasm selected for cylindrical shape and moderate sucrose content. TBEL1 was derived from an experimental hybrid between sugar beet and table beet as part of investigations into the inheritance of sucrose content and other characters in *Beta vulgaris.* The progenitors of TBEL1 and the advanced inbred lines that comprise TBEL1 have been evaluated and selected under field conditions typical of sugar beet production over four years at East Lansing, MI and Saginaw, MI. It is expected TBEL1 will be a source for development of new varieties of red table beets for canning, where the cylindrical shape results in less waste during the canning process compared with the standard globe beet shape, and better consumer acceptance due to higher sucrose content than available cylindrical beet types.

TBEL1 is self-fertile (S^f). Hypocotyls and roots are uniformly deep red in color due to the presence of betalin pigments. TBEL1 is a seed mixture of inbred lines derived by single seed decent for four generations from a single hybrid plant derived from a cross between C6869 sugar beet as the seed parent and W357B red table beet as the pollen parent. C6869 is an early generation selection leading to the USDA-ARS sugar beet germplasm release C869 (PI 628754). C6869 is self-fertile (*Sf*) and segregates for the multigerm character (*M_:mm*), genic-male-sterility (*A_:aa*), red hypocotyl (*R_:rr*), and resistance to rhizomania conferred by the *Rz1* allele. It is moderately resistant to the curly top virus, has wide variability for reaction to powdery mildew, Erwinia, and bolting, and has moderate levels of sucrose relative to modern sugar beet hybrids. C869 was derived from C6869 by four additional cycles of selection for these characters as well as for O-type (*xx, zz*) that confers cytoplasmic male sterility in an S-type sterile cytoplasm. W357B is a red table beet germplasm developed in the table beet breeding program at the University of Wisconsin by Dr. Buck Gabelman. The kind generosity of Dr. Gableman and Dr. Irwin Goldman in allowing this germplasm to contribute to the development of TBEL-1 is gratefully acknowledged. W357B is self-fertile (S^f), multigerm (*MM*), and O-type (*xx, zz*; referred to as a B-line in table beet breeding). It has been widely used in the generation of commercial table beet hybrids. Inbreeding was enforced in the greenhouse at East Lansing, MI by placing a white paper bag over each selected plant in each generation leading up to the S_5 generation of TBEL1.

TBEL1 comprises equal proportions of seed from 11 S_4 inbreds selected for elongated (length > twice diameter, ratio mean = 2.56 cm, standard deviation = 0.48 cm), dark red color, and emergence at the Saginaw Valley Bean and Beet Farm in Saginaw, MI in 2005. The 11 inbreds were evaluated as progeny from the S_4 plants 03B107-04, 03B112-02, 03B116-03, 03B137-03, 03B146-04, 03B156-02, 03B157-02, 03B157-03, 03B176-02, 03B187-02, and 03B203-02 in single replication plots of 3 m length and 1 m between rows. Each plant in these progeny plots was similar with respect to root shape and leaf morphology. Differences in smoothness of the skin were evident between inbreds. Mean fresh weight sucrose content in TBEL1 determined via near-infrared reflectance spectroscopy of five roots from each

inbred line was 13.69% (standard deviation = 1.24%). Mean root weight in TBEL1 was 731.4 g (standard deviation = 171.1. g) from the same roots analyzed for sucrose content. It should be noted that agronomic management of sugar and table beets is sufficiently different such that yield comparisons may be misleading. In this case, TBEL1 was evaluated at 126 days after planting.

The 11 S_4 components of TBEL1 stem from 10 S_3 lines, each S_3 from a different S_2 plant except in the case of 03B157-02 and 03B157-03 that share a common S_3 parent and 03B116-03 and 03B156-02 that share a common S_2 parent. Thus, TBEL1 is expected to contain a range of sugar and table beet alleles from which further selections can be effected. Sucrose content (fresh weight) in the S_3 populations leading to TBEL1 ranged from 8% to 19% (mean=12.15, std. dev.=2.82). All inbreds of TBEL1 are derived from a single S_1 individual, 99B004, which gave rise to 145 S_2 individuals used as a genetic mapping population. Due to the inbred nature of W357B, all of its alleles are expected to have been present in 98B004, which is not true for the heterozygous C6869 parent, and in this case only one sugar beet gamete was sampled in the lineage leading to TBEL1.

TBEL1 was developed by the ARS sugar beet breeding program at East Lansing, MI by Dr. J.M. McGrath with assistance from Dr. D. Trebbi of Michigan State University's Plant Breeding and Genetics Graduate Program. TBEL1 is being released as a germplasm source for breeders to use in developing improved table beet germplasm for processing and canning. Limited amounts of seed are available for use by submitting a request to Dr. J. Mitchell McGrath, USDA-ARS, 494 PSSB, Michigan State University, East Lansing, MI 48824-1325 (mitchmcg@msu.edu). Genetic material of this release will be deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new cultivars. It is requested that appropriate recognition be made if this germplasm contributes to the development of a new breeding line or cultivar. Plant variety protection will not be sought for this material.

NOTICE OF RELEASE OF EXPERIMENTAL SUGARBEET GERMPLASMS EL-X1, -X2, -X3, AND -X4 WITH WILD ANCESTRY AND SELECTION FOR APHANOMYCES RESISTANCE

The Agricultural Research Service of the U. S. Department of Agriculture, the Beet Sugar Development Foundation, and Michigan State University announce the joint release of four experimental sugarbeet germplasms EL-X1, EL-X2, EL-X3, and EL-X4. These experimental germplasms were last selected at the Betaseed, Inc. Aphanomyces nursery in Shakopee, MN in 2003 by Margaret Rekoske and Jay Miller, followed by seed production at Shakopee, MN in 2004. The derivation of these materials is varied (below), but all share the common goal of understanding and broadening the genetic base for Aphanomyces resistance in sugar beet. These lines may be useful for a number of basic and applied investigations, and limited quantities of seed are being made available to facilitate further testing and development of these and additional goals since wild beet germplasm has been used in their development.

Construction and evaluation of original and derived materials was done in the program of J. Mitchell McGrath, USDA-ARS East Lansing MI beginning in 1997. These lines are not currently suitable for variety development since they still have many characteristics of wild materials, however they have some improvement in taproot characteristics relative to the wild accessions. In 2003, 64 genetically similar entries, standards and the sugarbeet parents were tested in the Shakopee Aphanomyces nursery and rated on a 1 (resistant) to 9 (susceptible) scale. The average of two Aphanomyces tolerant and two susceptible standards was 2.0 and 7.0, respectively ($LSD_{0.05}$=1.83, average of two late readings), the sugar beet parents SP6822 and 6869 had scores of 1.0 and 5.5, respectively, and the four entries that showed the greatest potential, releases EL-X1 to –4, scored 2.75, 4.50, 4.00, and 3.75, respectively. From this nursery in 2003, approximately 20 roots were selected for improved root conformation and relative freedom from disease from within each release. Subsequently seed of each release was produced by inter-pollination of the selected plants the following year.

WB879, a wild *Beta vulgaris* spp. *maritima* accession (PI 540625) collected in 1989 on the coast of Brittany, France, was used as the wild beet donor germplasm in EL-X1 and EL-X4. WB879 was used because its potential resistance to Aphanomyces diseases caused by *Aphanomyces cochlioides* by having a disease score of 1 (resistant) (rating system of 0-9 scale with 0 showing no symptoms and 9 being dead) in the 1994 Beta germplasm evaluation nursery conducted by C.M. Rush in Amarillo, Texas (Sugarbeet.Aphan.94.Rush; http://www.ars-grin.gov/cgi-bin/npgs/html/eval.pl?269). WB879 is diploid, biennial, and has resistance reported for beet western yellows virus and *Polymyxa betae*. Similarly, the wild beet parent of EL-X3, WB185 (PI 546409), also had an Aphanomyces score of 1.0 in the 1994 Beta germplasm evaluation nursery, and was collected near Plymouth, England. WB185 is diploid, biennial, prostrate, with reported resistance to Cercospora leaf spot and *Polymyxa betae*. SP6822 (PI 615525), as a traditional Aphanomyces resistance source, and 6869 (a progenitor of C869, PI 628754) as a donor of the self-fertility (S^f) and nuclear male sterility characters, or both, were used as sugar beet parents. Each of these releases is expected to be self-fertile and segregating for nuclear male sterility, and in all cases, tested seed was harvested from the sugar beet parent.

EL-X1 (4PS1926) was constructed as seed mixture of nine independent F_1 hybrids between a single plant each of WB879 and SP6822. The F_1 hybrids were grown in an observation nursery in Saginaw, MI in 1998 and 30 roots were selected for plant vigor. In the greenhouse, all plants were male sterile, and were pollinated with the self-fertile line 6869. Seed was harvested from individual plants, and nine of these seed harvests were combined later to obtain sufficient seed for Aphanomyces testing at Shakopee, MN in 2003. Other progeny were previously tested in this nursery previously and in the Saginaw Valley Bean and Beet Farm seedling disease nursery between 2001 and 2004, with wide variability observed in plant morphology and disease reaction.

EL-X2 (4PS1927) was constructed from a cross between a single male sterile plant of 6869 and a single plant of SP6822 as its pollinator. F_1 seed from this cross was planted in the 1998 observation nursery in Saginaw, MI, and one plant, designated 98B001-26, was selected for plant vigor, and selfed S_2 seed was produced in the 1999 greenhouse. S_2 seed was planted in the 2000 Saginaw Valley Bean and Beet Farm seedling disease nursery, and three roots designated 00B031-1 to -3 were selected as free from disease at the end of the season, and inter-crossed to give rise to the seed from which EL-X2 was selected in Shakopee, MN. EL-X2 serves as a comparison for Aphanomyces tolerance relative to the other releases here that used WB879 or WB185 in their lineage, relative to the traditional high level of resistance shown by SP6822.

EL-X3 (4PS1928) was constructed from a cross between single plants of WB185 and 6869, and F_1 seed was planted in the Saginaw observation nursery. 21 plants were selected for vigor, and self-pollinated in the greenhouse to produce S_2 seed. S_2 seed of these 21 lines was combined and grown in the 2003 Aphanomyces nursery in Shakopee. Plants with reasonably evident taproots and few disease symptoms were selected and increased in Shakopee.

EL-X4 (4PS1929) is from the cross between a single WB879 plant and the same 6869 plant used for EL-X3. F_1 seed from this cross was planted in the 1998 observation nursery in Saginaw, MI, and seven roots were selected on plant vigor, and selfed S_2 seed was produced in the 1999 greenhouse. S_2 seed was provided for the Shakopee Aphanomyces nursery, and seed was produced from selections within the nursery that had low disease incidence and improved root shape (e.g. lack of sprangled roots).

These EL-X (for experimental) lines are being released as a germplasm resources for breeders to use in developing parental lines with potentially new sources of resistance to diseases caused by Aphanomyces. These lines also contain a series of useful characters at low allele frequencies derived from the parent's components, such as those necessary to breed for seed parents used to create cytoplasmic male sterility-mediated hybrids. Seed will be available for use by writing to Dr. J. Mitchell McGrath, USDA-ARS, 494 PSSB, Michigan State University, East Lansing, MI 48824-1325 (mitchmcg@msu.edu), pending seed increase. Genetic material of this release will be deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new cultivars. Efforts of Yi Yu, Tim Duckert, and Teresa Koppin as well as Betaseed, Inc. in generating these materials are gratefully acknowledged. It is requested that the author be notified if this germplasm contributes to the development of a new breeding line or cultivar. U.S. Plant Variety Protection will not be requested.

SUGARBEET RESEARCH
USDA-ARS MOLECULAR PLANT PATHOLOGY LABORATORY
BELTSVILLE, MARYLAND

2005 REPORT

SECTION E

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This research was supported in part by funds provided through the Beet Sugar Development Foundation. (Projects 811and 831)

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CLONING OF *BETA VULGARIS* ROOT ESTs MODULATED BY SUGAR BEET ROOT MAGGOT FEEDING: ROLE OF PROTEINASE INHIBITORS IN INSECT RESISTANCE

(Project 811)

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PROTEINASE INHIBITOR GENES FOR INSECT CONTROL:

Assimilation of dietary proteins is critical to insect survival; therefore, inhibition of digestive enzymes presents itself as an excellent target for development of novel strategies for insect control. Proteinase inhibitors (PI) are enzymes that occur naturally in a number of plant species. PIs often accumulate in tissues in response to wounding or herbivory and are considered an important element of natural plant defense mechanisms. Although the exact mode of action of the PIs is not fully understood, their ingestion by insects can result in reduced growth and/or survival of the insect. Their role in combating insect predators is supported by findings that higher levels of more than one PI have been found in insect resistant vs. susceptible plants and that incorporation of PIs into artificial feeding diets had a deleterious effect on insect development. Insects were shown to suffer considerable effects from the presence of the PI even in cases where the insects were able to produce more proteases that were insensitive to a given PI and break down the ingested PI by non-targeted proteases. Similarly, a combination of PIs in insect diets proved more toxic at levels where individual inhibitors were not effective.

To devise a rational control strategy based on the expression of PI genes in transgenic plants, it is first necessary to characterize the digestive enzymes utilized by the targeted pest. Digestive proteases are grouped into four classes based on the amino acid residue or metal ion involved in peptide bond catalysis: (*i*) serine, (*ii*) cysteine (or thiol), (*iii*) aspartyl (or carboxyl), and (*iv*) metalloproteinases. Serine proteases are primarily associated with lepidopteran species and cysteine proteases with coleopteran and some homopteran insects. In order to identify the major digestive proteinases in the midguts of the most devastating pest of sugar beet, the sugar beet root maggot (SBRM, *Tetanops myopaeformis* Röder), we examined the effect of pH, low-molecular weight inhibitors, and plant-derived PIs on substrate hydrolysis in the presence of midgut extracts of second instar SBRM. We determined that there are two major classes of protease activity, serine and aspartyl, in SBRM midgut extracts. These serine and aspartyl proteases are consistent with what has been reported for other dipteran insects, although generally only a single major protease has been reported for a particular insect. We demonstrated that the activities of the SBRM digestive proteases were effectively blocked by a soybean trypsin-chymotrypsin and a squash aspartyl PI (Wilhite et al., 2001).

A number of plant PI genes have been cloned, reconstructed and expressed in transgenic plants and shown to enhance insect or nematode tolerance. In one particular report, a *Nicotiana alata* gene that is posttranslationally cleaved into five individual trypsin/chymotrypsin PIs was over-expressed in transgenic plants and shown to effectively target insects representing four different insect orders, including a dipteran insect.

PI genes have been co-expressed (stacked) with other resistance genes and shown to effectively reduce buildup of resistance in the targeted pest or pathogen. Gene stacking approaches are successfully being used to address the limitations that are being encountered with cultivation of genetically engineered plants, i.e. increased occurrence of resistance in the targeted pest (Mehlo et al., 2005).

SBRM-RESPONSIVE CDNAS: PI GENE CLONING:

Damage from SBRM is a serious problem in the North Central and Western United States and Canada. More than two-thirds of the 1.5 million sugar beet-producing acres in the United States are infested with SBRM. A handful of chemical insecticides have been in use for over 30 years, and recent concerns with regards to pesticide safety and potential for resistance development have serious implications for the profitability of sugar beet production in the future. Alternative methods of control need to be identified and pursued since germplasm with complete resistance to SBRM is not available (Smigocki et al., 2003).

We recently identified sugar beet root ESTs that are modulated by SBRM feeding in both a moderately resistant (F1016) and a susceptible parental (F1010) line (Puthoff and Smigocki, 2005; 2006). One of the genes, *BvSTI*, is specifically up-regulated in the moderately resistant F1016 germplasm by SBRM infestations. *BvSTI* encodes a protein with a conserved motif denoting it a member of the Kunitz trypsin (serine) proteinase inhibitor family. *BvSTI* also shares similarity with a tomato gene that is primarily expressed in the root, secreted to the rhizosphere and induced by nematodes. Since we showed that serine and aspartyl proteases comprise the major digestive enzymes in root maggot midguts (Wilhite et al. 2001), our findings suggest that BvSTI may form a zone of protection surrounding the moderately resistant roots and act as a first line of defense in the peripheral cell layers.

To functionally characterize the role of *BvSTI* in mediating resistance to SBRM, we obtained the full length coding sequence of *BvSTI* from the cloned EST using 5' and 3' RACE. The full length coding sequence was then cloned into a plant transformation vector cassette (Figure 1). Using strategically designed PCR primers, we created a pCAMBIA1301 expression cassette that allows the swapping of full length coding sequences (FLCS) and promoter regions of candidate genes (Figure 1). This cassette will allow for rapid reconstruction of interesting genes for subsequent introduction into plants for gene promoter characterization and FLCS functional assessment. PCR utilizing gene specific primers was used to also clone a squash PI gene. The squash PI gene codes for a 10.5 kDa protein that does not share sequence homology with any known protein. Similarly, we cloned the *N. alata* gene that is posttranslationally cleaved into five individual trypsin/chymotrypsin PIs (Figure 1). The five *N. alata* PIs encode a 6 kD chymotrypsin and four 6 kDa trypsin inhibitors.

ROOT-SPECIFIC EXPRESSION IN SUGAR BEET HAIRY ROOTS:

Hairy root cultures were established with the reconstructed PI genes via *A. rhizogenes*–mediated transformation of F1016 and F1010 petioles (Smigocki et al., 2005). Each of the 3 PI genes was introduced individually and in different combinations, i.e. stacked, in order to pyramid the effect of the inhibitors. Taproot-specific expression of the PI genes will target the production of the inhibitors to the site of insect attack. Preliminary analysis of hairy roots transformed with the GUS gene fused to a constitutive, root specific promoter indicated good levels of root expression in the established hairy root cultures (Figure 2).

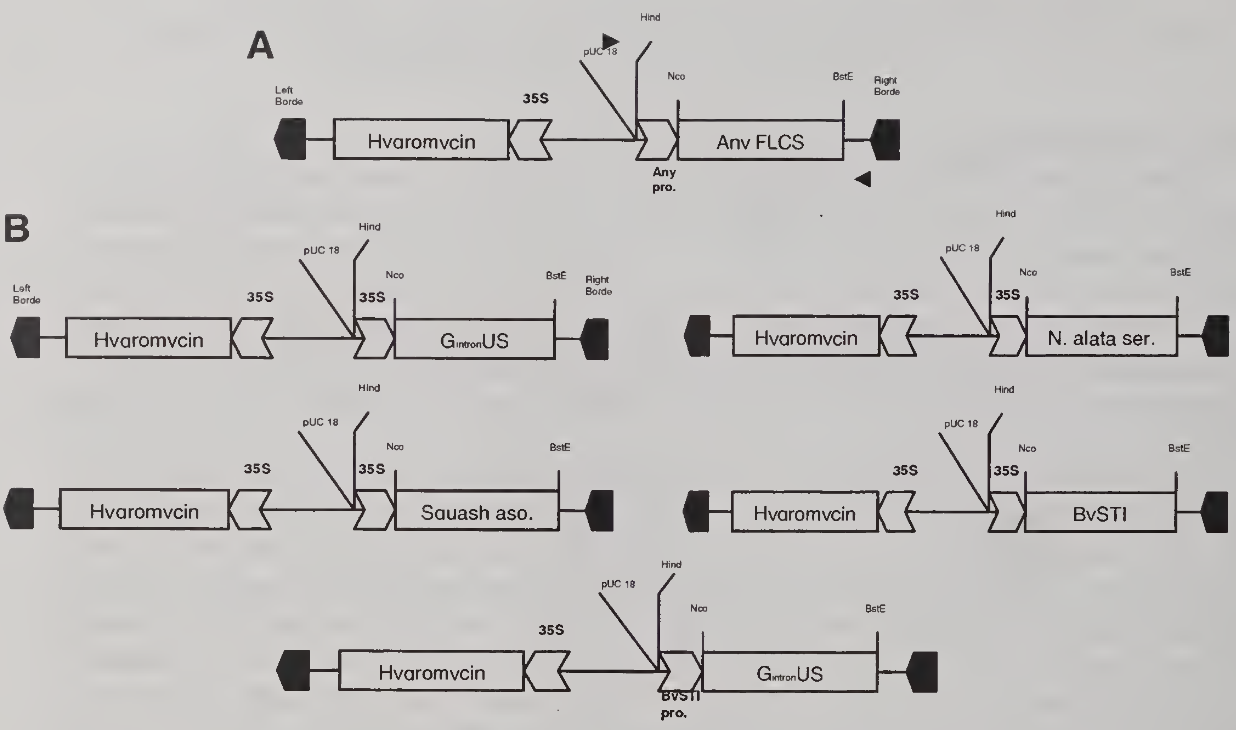

Figure 1. pCAMBIA1301 plant transformation vectors carrying various PI gene. FLCS, full length coding sequence; pro., promoter; 35S, CaMV35S promoter; GintronUS, intron interrupted GUS gene; *N. alat*a ser., *Nicotiana* serine PI; squash asp., squash aspartyl PI; BvSTI, sugar beet trypsin PI.

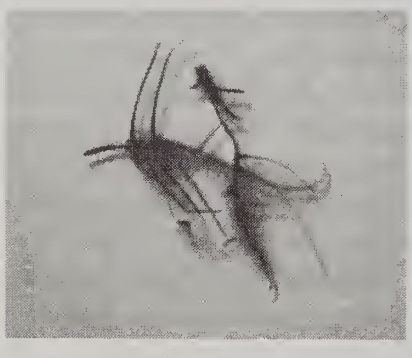

Figure 2. GUS+ sugar beet hairy roots transformed with the *GUS* gene fused to a constitutive, root specific promoter.

SUGARBEET ROOT MAGGOT BIOASSAY:

Development of efficient insect bioassays is imperative for rapid screening of resistance resources in order to design effective tools for control of insect pests. The inability to rear SBRM larvae in the laboratory and a need to utilize mature sugar beet taproots have collectively hindered rapid progress towards development of new control measures. We recently developed an *in vitro* SBRM larval bioassay technique using sugar beet seedlings and hairy root cultures (Smigocki et al., 2005; 2006). Development of this technology facilitates studies of root-SBRM interactions under controlled conditions and also provides means for rapid analysis of the effects of resistance genes and mechanisms in sugar beet roots.

Infestation of sugar beet hairy roots with first-instar SBRM revealed their preference for the susceptible F1010 germplasm. Since first-instars are barely visible to the naked eye, the pattern of larval movement and feeding on hairy roots was tracked by the residual trail of contamination from the non-sterile larvae on antibiotic- and fungicide-free medium. Dense, circular, swirling and roaming trails away from the F1016 roots were observed (Figure 3A). In contrast, the trail of contamination on F1010 hairy roots was confined to the area immediately surrounding the roots, thus depicting the mobility of the larvae along the lengths of the roots (Figure 3B).

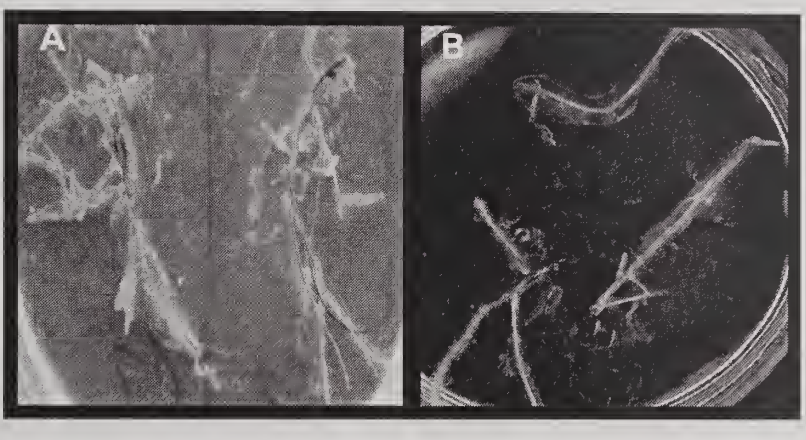

Figure 3. SBRM bioassay using hairy root cultures of moderately resistant F1016 and susceptible F1010 sugarbeet lines. (A) F1016 hairy roots infested with first-instar SBRM at 48 hr after infestation depicting dense circular and swirling trail of contamination corresponding to the movement of the larvae. (B) SBRM-infested F1010 hairy roots with the trail of contamination being confined to the area immediately flanking the roots.

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PROGENY FROM GENETIC CROSSES OF *CFP* TRANSGENIC T7#12 WITH TWO SALINAS GENOTYPES

(Project 831)

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Cercospora-induced leafspot disease is a serious problem for sugarbeet production in most of the U.S. growing regions. Since conventional plant breeding has thus far successfully produced only moderate leafspot resistance, a biotechnological approach has been pursued since 1998. We introduced the cercosporin toxin export gene CTP from *Cercospora kikuchii* into *Beta vulgaris* L. using inter-kingdom bacterial conjugation. The biotechnology clone 'Rel-1', developed by the late J. Saunders, ARS/USDA in East Lansing, Michigan, was agrotransformed. The expression of both transcribed RNA and translated protein was detected using reverse transcriptase PCR and Western blot analyses. In 2004, a number of viable seeds were produced and sent to the Sugar Beet Research Unit at Fort Collins, CO where crosses were performed, in 2004 and 2005, using lines C842 and 9933 from the program of R.T. Lewellen, USDA-ARS, Salinas, CA. The evaluation of the level of *Cercospora* leafspot resistance of the progeny is planned.

JUSTIFICATION FOR RESEARCH:

The phytopathogenic fungal species *Cercospora beticola* Sacc. causes leafspot, the most serious widespread disease of sugarbeet in most sugarbeet production areas. ARS Plant Pathologist John Weiland in North Dakota documented significant genomic diversity among the *Cercospora* fungi that cause leafspot disease in sugarbeet (Weiland, 2004). Leafspot destroys mature, highly photosynthetic leaves, which are replaced by the growth of new leaves at the expense of carbohydrate stored in the root, thereby reducing root yield, percent sucrose, and purity. *Cercospora* leafspot currently is controlled using moderately disease resistant germplasm, and timely foliar spraying with expensive commercial fungicides. The use of biotechnology to improve *Cercospora* leafspot resistance in sugarbeet would be a sustainable solution. Especially since *Cercospora* are becoming tolerant to fungicides, genetic resistance to this serious pathogen is needed.

SUMMARY OF LITERATURE REVIEW:

Cercospora leafspot has long been a serious disease problem in the sugarbeet growing areas of the United States where the summers are often hot and humid (Red River Valley, Michigan, Ohio, and, less often, Great Plains growing areas and California). It has been estimated that a severe epidemics cause as much as a 40% loss of sugar yield (Smith and Martin, 1978; Smith and Ruppel, 1973) and a corresponding, equal loss in farm revenue (Shane and Teng, 1992).

Resistance to *Cercospora* leafspot has long been a goal of the USDA-ARS sugarbeet research program and researchers at Fort Collins, CO long ago developed the techniques necessary to manage screening nurseries carefully to promote the development of the disease (Ruppel and Gaskill, 1971). Crop rotation with barley, along with the area's dry climate and low relative humidity ensures that the results are rarely tainted by other disease-causing

organisms. Tolerance to *Cercospora* leafspot is defined as a plant genotype performing well despite the presence of symptoms of the disease (Fehr, 1987).

Generally the *Cercospora*-resistant germplasm in use today was originally derived from outcrosses with *B. vulgaris* spp *maritima* to import resistance genes; this early plant breeding had been done by Munerati in Italy (Lewellen, 1992). With this genetic source, an estimated 4 or 5 genes are thought to be involved in conferring moderate *Cercospora* leafspot resistance (Smith and Gaskill, 1970). Broad-sense heritability estimates range from 12 to 71% (Bilgen *et al.*, 1969), narrow-sense heritability is 24% comparing well with realized heritability, and about 50% of the variation is environmental (Smith and Ruppel, 1974). This high degree of environmental variation makes the development of resistance through mass selection difficult. Incorporation of *Cercospora* leafspot resistance into varieties with superior agronomic performance is also difficult (Smith and Campbell, 1996) and, therefore, commercial resistant varieties require some fungicide application to provide adequate levels of protection against *Cercospora* (Miller *et al.*, 1994).

A major problem in the development of *Cercospora* leafspot resistant sugarbeet is the loss of vigor due to the continual inbreeding (Coons, 1955 and McFarlane, 1971). The use of hybrid varieties has lessened this problem to an extent, but seed production on the highly inbred O-type males and CMS females continues to be a problem. This creates an urgent need to continue to the development of a broader genetic base of *Cercospora* leafspot-resistant germplasm. As commercial hybrid parents become more inbred, there must be sufficient diversity in the germplasm base for maximum gain through heterosis. In addition to broadening the genetic base of the commercial sugarbeet germplasm, novel genes for resistance to *Cercospora* leafspot resistance might lead to transgression of tolerance to *Cercospora* leafspot (de Vicente & Tanksley, 1993).

The non-host specific phytotoxic polyketide cercosporin is a lipid-soluble perylenequinone that, upon light activation, catalyzes the production of highly reactive oxygen species, principally singlet oxygen (Daub, 1982). Singlet oxygen-catalyzed peroxidation of membrane lipids results in loss of membrane integrity, cytoplasmic leakage and cell death (Daub & Ehrenshaft, 2000). *Cercospora* hyphae enter the host plant passively through open stomata and grow intercellularly. Toxin-mediated disruption of the cellular membranes of host cells provides the pathogen with nutrients for *in situ* growth and sporulation.

Recent studies have focused on identifying genes for resistance to cercosporin in *Cercospora* fungi themselves (Daub & Ehrenshaft, 2000). One such resistance mechanism apparently involves the export action of the Major Facilitator (MF)-like protein gene, CFP, which was isolated from *C. kikuchii* (Callahan *et al.*, 1999). Targeted disruption of the CFP gene resulted in mutants that lacked virulence on soybean and were inhibited by cercosporin. Cercosporin export was substantially elevated in CFP multi-copy strains of *C. kikuchii* that over-expressed CFP protein (Upchurch *et al.*, 2001). Moreover, transgenic expression of CFP in the cercosporin sensitive fungus *Cochliobolus heterostrophus* resulted in significantly increased cellular resistance to the toxin (Upchurch *et al.*, 2002). Cercosporin-deficient mutants of *C. kikuchii* do not produce lesions on soybean, indicating that cercosporin is an essential virulence factor (Upchurch *et al.,*. 1991).

Kanamycin-resistance clones were regenerated *in vitro* following conjugal mating of wounded REL-1 leaf pieces with *Rhizobium radiobacter* carrying pCFP. Transgenic plants were confirmed by PCR of leaf DNA using *CFP*-specific primers (Kuykendall *et al*, 2003).

Moreover, vegetatively propagated kanamycin-resistant plants and seed-grown transgenic REL-1 plants stably maintained the ability to produce a DNA product of the approximate size predicted for PCR using the *CFP*-specifc primers. Expression of the transgene in sugarbeet was reported in 2004 (Kuykendall and Upchurch).

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OBJECTIVES

1. The evaluation of *Cercospora* leafspot resistance in transgenic sugar beet genotypes, relative to parental germplasm tolerance--- is CFP useful in enhancing leafspot resistance in sugar beet? (Proof of Concept).

2. The development of progeny from crosses of the T7#12 transgenic sugarbeet with high quality genotypes C842 and 9933 developed by Bob Lewellen in Salinas, CA.

MATERIALS AND METHODS:

We plan to use seeds obtained from the transgenic genotype PT7#12 to develop plants for *Cercospora* leafspot evaluation. Controlled environmental conditions in a growth chamber will be used. Seeds from greenhouse-grown T7#12 seed were sent to Lee Panella in Ft. Collins, CO to cross. Transgenic plants were crossed in Ft. Collins with sugarbeet genotypes ‘C842’ and ‘9933’ both out of Salinas, CA (See Table below). Seed from the crosses of CFP transgenic T7#12 with these sugarbeet genotypes have been received in Beltsville. Thirty

progeny from the male sterile parent of three such crosses are being grown out in the greenhouse for the evaluation of *Cercospora* leafspot resistance (to be performed in a growth chamber).

Genotype C842 is released from Salinas – It is rhizomania resistant (RhzmR), monogerm (*mm*), self-fertile (S^f), Curly top resistant (CTR), segregating for genetic male sterility (*A-:aa*), and green hypocotyl color (*R-:rr*), - it is a facilitated random mated population with variable reaction to bolting, Erwinia, and powdery mildew.

Genotype 9933 comes from 8933, which consists of - #s *aa* x *A*. It is rhizomania resistant (RhzmR), multigerm (*MM*), self-fertile (S^f), Curly top resistant (CTR), Virus yellows resistant (VYR), Powdery mildew resistant (PMR), Erwinia resistant bolting resistant, segregating for genetic male sterility (*A-:aa*), root aphid resistance, and green hypocotyl color (*R-:rr*) w/ normal cytoplasm.

T7#12, a transgenic sugarbeet (*Beta vulgaris* L.), was derived from clone 'Rel-1' by agrotransformation with the cercosporin toxin export gene CFP from *Cercospora kikuchi.*

TIME LINE OF ANTICIPATED ACCOMPLISHMENTS:

The evaluation of *Cercospora* leafspot resistance in transgenic sugarbeet genotypes, relative to parental germplasm tolerance, is planned to evaluate the concept that the CFP gene can enhance leafspot resistance in sugarbeet. The progeny from crosses of the T7#12 transgenic with high quality genotypes C842 and 9933 developed by Bob Lewellen in Salinas, CA should permit evaluation of the influence of the CFP gene on *Cercospora* leafspot susceptibility in sugarbeet .

Thus, this year we plan to evaluate whether CFP expression in transgenic sugarbeets can enhance *Cercospora* leafspot resistance.

RESEARCH PROGRESS 2005 AND PLANS FOR 2006:

We now have the progeny resulting from 33 crosses of T7#12 with genotypes C842 and 9933. Evaluations of these crosses will begin in the summer of 2006 and results will be reported in next year's BSDF annual report. Emphasis will be placed on the progeny of 20 crosses in which genetic male sterility was used, and 30 progeny from three such crosses are now being grown out in the greenhouse for *Cercospora* leafspot evaluation.

Greenhouse Crosses from January, 2005 through January, 2006.

orange	**2004A001,**	**PT7#12**	**transgenic**	**Kuykendall**
blue	**2004A002**	**C842**	**biennial**	**Lewellen**
yellow	**2004A013**	**9933**	**biennial**	**Lewellen**
Color Stake	**Hypocotyl color**	**PF or MS**	**Plant #**	**Assigned number**
Orange	Pink	PF	#1	20041021H-01s
Blue	Pink	MS	#1	20041021H2-01
Orange	Pink	PF	#2	20041021H-02s
Blue	Pink	MS	#2	20041021H2-02
Orange	Pink	PF	#3	20041021H-03s
Blue	Pink	MS	#3	20041021H2-03
Orange	Pink	PF	#4	20041021H-04s
Yellow	Pink	MS	#4	20041021H3-04

Orange	Green	PF	#5	20041021H-05s
Yellow	Pink	PF	#5	20041021H3-05
Orange	Pink	PF	#6	20041021H-06s
Blue	Pink	MS	#6	20041021H2-06
Orange	Pink	PF	#7	20041021H-07s
Blue	Pink	MS	#7A	20041021H2-07A
Blue	Green	PF	#7B – after 7A died	20041021H2-07B
Orange	Pink	PF	#9	20041021H-09s
Yellow	Green	MS	#9	20041021H3-09
Orange	Pink	PF	#10	20041021H-10s
Yellow	Pink	MS	#10	20041021H3-10
Orange	Pink	PF	#12	20041021H-12s
Blue	Green	PF	#12	20041021H2-12
Orange	Pink	PF	#13	20041021H-13s
Blue	Pink	MS	#13	20041021H2-13
Orange	Pink	PF	#14	20041021-14s
Blue	Pink	MS	#14	20041021H2-14
Orange	Pink	PF	#15	20041021H-15s
Blue	Green	MS	#15	20041021H2-15
Orange	Pink	PF	#16	20041021H-16s
Blue	Green	MS	#16	20041021H2-16
Orange	Pink	PF	#18	20041021H-18s
Blue	Green	PF	#18	20041021H2-18
Orange	Green	PF	#19	20041021H-19s
Blue	Pink	PF	#19	20041021H2-19
Orange	Pink	PF	#20	20041021H-20s
Yellow	Green	PF	#20	20041021H3-20
Orange	Pink	PF	#23	20041021H-23s
Blue	Pink	MS	#23	20041021H2-23
Orange	Green	PF	#25	20041021H-25s
Blue	Pink	MS	#25	20041021H2-25
Orange	Green	PF	#27	20041021H-27s
Blue	Pink	MS	#27	20041021H2-27
Orange	Pink	PF	#30	20041021H-30s
Blue	Pink	MS	#30A	20041021H2-30A
Blue	Green	PF	#30B – after 30A died	20041021H2-30B
Orange	Pink	PF	#33	20041021H-33s
Blue	Pink	MS	#33B	20041021H2-33A
Blue	Pink	MS	#33B	20041021H2-33B
Orange	Pink	PF	#34	20041021H-33s
Blue	Pink	MS	#34	20041021H2-34
Orange	Pink	PF	#41	20041021H-41s

Blue	Pink	MS	#41	20041021H2-41
Orange	Pink	PF	#42	20041021H-42s
Blue	Pink	MS	#42	20041021H2-42
Orange	Green	PF	#43	20041021H-43s
Pink	Blue	MS	#43	20041021H2-43
Orange	Green	PF	#44	20041021H-44s
Blue	Pink	MS	#44	20041021H2-44
Orange	Pink	PF	#45	20041021H-45s
yellow	green	PF	#45	20041021H3-45
Orange	Green	PF	#46	20041021H-46s
Blue	Pink	MS	#46	20041021H2-46s
Orange	Pink	PF	#55	20041021H-55s
Blue	Pink	MS	#55	20041021H2-55
Orange	Pink	PF	#56	20041022H-56s
Blue	Green	PF	#56	20041021H2-56

SUGARBEET RESEARCH
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This research was supported in part by funds provided through the Beet Sugar Development Foundation (Project 508)

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CHARACTERIZING DIVERSITY OF BNYVV IN FIELDS PLANTED TO RHIZOMANIA RESISTANT VARIETIES

(Project 508)

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Beet necrotic yellow vein virus (BNYVV), which causes rhizomania of sugar beet, causes major reductions in root yield and quality wherever it occurs. When the pathogen is first introduced into a field, yield losses may be minimal. However, in subsequent crops, root yield and quality are both significantly reduced. In the United States, the disease was first identified in California in 1984, but now it occurs in every major sugar beet production region in the country. Fortunately, strong genetic resistance, conferred by the *Rz1* gene, was identified soon after rhizomania was identified in the United States, and it has been incorporated into regionally adapted cultivars that allow profitable sugar beet production in fields infested with the pathogen. However, in the Imperial Valley of California in 2002, plants in a field planted to a rhizomania resistant cultivar began to express symptoms of rhizomania. Severe rhizomania has also occurred in Minnesota sugar beet fields planted to rhizomania tolerant cultivars. In Minnesota, the occurrence of rhizomania in disease tolerant cultivars was primarily restricted to individual plants. However, in 2004 and 2005 discrete spots of diseased plants appeared and this essentially ruled out "seed issues" as the cause for disease development. Therefore, inoculum density of viruliferous *P. betae,* soil edaphic factors, or a new resistance-breaking strain of BNYVV is likely the reason for disease development in rhizomania resistant cultivars. It is important to determine how extensive breakdown of rhizomania resistance is in the United States, whether the etiology of rhizomania in fields planted to rhizomania tolerant cultivars is the same in different production regions, and to devise strategies for managing the problem. One of the goals of our research on rhizomania is to investigate the cause and incidence of rhizomania in fields planted to disease tolerant cultivars. In order to meet this goal, we conducted studies in 2005 with the following objective: 1) Detect and map genetic variation among resistance-breaking isolates of BNYVV.

METHODS:

Objective 1. Detect and map genetic variation among resistance-breaking isolates of BNYVV. Sugar beet plants exhibiting typical, diagnostic symptoms of rhizomania were collected from fields planted to rhizomania tolerant cultivars in California and Minnesota. Since the *Rz1* gene only confers tolerance to BNYVV and does not prevent infection of the root, asymptomatic beets were also collected from the same fields where resistance was breaking down in hopes of obtaining wild type, non resistance-breaking isolates of BNYVV. Symptomatic and asymptomatic plants were taken to the TAES plant pathology lab in Amarillo and total RNA was extracted from all plants. Extracted RNA was used to generate cDNA, which in turn was used as template for PCR amplification. Specific primers for RNA 3, the RNA species which has been associated with symptom expression and disease severity, were used to amplify the entire P25 ORF on RNA 3. DNA bands of the expected size were generated. The DNA bands were excised from the electrophoresis gel and these were gel purified and sent off for sequencing. Sequence data was analyzed using a variety of DNA analysis software programs.

RESULTS AND DISCUSSION:

Results of the study on genetic variability among isolates of BNYVV are shown in Table 1. In greenhouse studies, resistance-breaking isolates of BNYVV from California were highly virulent on cultivars that contained the *Rz1* gene, and virus titers were high in infected plants. Wild type isolates from the same fields were not able to replicate well in rhizomania tolerant cultivars and virus titers were significantly lower than those achieved by the resistance-breaking isolates (data not shown). Sequence analysis of the RNA 3 P25 ORF from the different isolates of BNYVV revealed a high degree of nucleotide sequence homology. However, amino acid analysis revealed differences between California wild type isolates and resistance-breaking isolates of BNYVV. The resistance-breaking isolates from California were also genetically distinguishable from isolates of BNYVV obtained from blinkers in Minnesota (Table 1). Amino acids 67,68, and 135 from the P25 RNA3 ORF can be used to distinguish the California resistance-breaking isolates of BNYVV from all other isolates but it is uncertain whether the $V_{67}L_{68}E_{135}$ motif associated with the resistance-breaking isolates is actually responsible for the ability of these isolates to overcome *Rz1*. The fact that the amino acid motif of isolates from blinkers in Minnesota differs from the California resistance-breaking isolates suggests that the two are genetically distinguishable and that perhaps mechanisms of virulence are different. However, additional tests need to be performed to verify this hypothesis.

Table 1. Amino acid substitutions in the *Beet necrotic yellow vein virus* P25 protein, associated with resistant breaking isolates and blinkers from California and Minnesota, respectively.

Source	Isolate[y]	Amino acid[z]		
		67	68	135
California	Ch*	V	L	E
	Mag*	V	L	E
	DWe*	V	L	E
	Spr*	V	L	E
	Tam*	V	L	E
	Salinas 2005	A	C	D
	Wt CIV2005	A	L	D
Minnesota	Blinker 83*	V	C	D
	Crookston*	A	H	D
	Willmar*	A	C	D
	Glendon 1*	A	C	D
	Climax*	A	C	D
	Wt15 2000	A	C	D

[x] Blinker are individual sugar beets infected by *Beet necrotic yellow vein virus* (BNYVV), which exhibit florescent yellow foliage associated with rhizomania.

[y] Isolates followed by an asterisk "*" represent resistance-breaking CIV-BNYVV from California, or BNYVV isolates recovered from blinkers in Minnesota. Salinas 2005 and Wt CIV 2005 represent wild type, non-resistance breaking isolates from Salinas, CA and the Imperial Valley, respectively.

[z] The $V_{67}L_{68}E_{135}$ signature was consistently found in resistance-breaking CIV-BNYVV populations during 2005. Asymptomatic plants from the Imperial Valley are infected by genetically heterogeneous virus populations where $A_{67}L_{68}D_{135}$ is the predominant signature. The $A_{67}C_{68}D_{135}$ signature has been found in many virus populations collected outside of the Imperial Valley, both from symptomatic and asymptomatic plants.

Although isolates of BNYVV obtained from blinkers in Minnesota were genetically different from resistance-breaking strains from California, they were obviously highly virulent and caused significant reductions in root yield and sucrose content (Table 2). Mean root weight of blinkers was reduced approximately 62% compared with asymptomatic, healthy beets growing adjacent to the blinkers. Blinkers also had reduced sucrose content that averaged 1.8 percentage points lower than the healthy beets.

Table 2. Disease rating and yield data from ground truthed plots

Symptom	Disease Rating[y]	Mean Root Wt.(lbs)	Sucrose (%)
Healthy	1.7	1.3	14.6
Blinker[x]	2.5	0.5	12.8

[x] Blinker is the term used to describe an individual sugar beet infected by BNYVV, which exhibits the florescent yellow foliage typically associated with rhizomania, surrounded by healthy beets with dark green foliage.

[y] Severity of rhizomania was based on a 0 – 4 scale, where 0 = healthy disease free roots and 4 = severe stunting, root constriction, and massive root proliferation.

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SECTION G

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This research was supported in part by funds provided through the Beet Sugar Development Foundation (Project 840)

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PUBLICATIONS RESULTING FROM BSDF SUPPORT

Coruzzi, G. and D. R. Bush. 2001. Nitrogen and carbon nutrient and metabolite signaling in plants. *Plant Physiol* **125**: 65-68.

Vaughn, M. W., Gregory N. Harrington and D. R. Bush. 2002. Sucrose-mediated transcriptional regulation of sucrose symporter activity in the phloem. *Proc. Natl. Acad. Sci. USA* **99**:10876-10880.

Ransom-Hodgkins, W., M. W. Vaughn and D. R. Bush. 2003. Protein phosphorylation mediates a key step in sucrose-regulation of the expression and transport activity of a beet proton-sucrose symporter. *Planta* **217**:483-489.

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Bush, D. R. 2004. Functional analysis of proton-coupled sucrose transport. *In:* Membrane Transport in Plants. *Ed.* Michael Blatt. p. 135-147 Blackwell Publishing.

NEW STRATEGIES FOR MODIFYING SUCROSE DISTRIBUTION IN SUGARBEEET
(Project 840)

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JUSTIFICATION OF RESEARCH:

Sucrose accumulated in the sugar beet tap root is synthesized in the leaf and then transported to the root in the phloem cells of the plant's vascular system. The proton-coupled sucrose transport protein mediates the key step in the long-distance transport of newly synthesized sucrose from the leaf to the taproot because it is responsible for sucrose accumulation into the leaf phloem cells and that activity drives sucrose flux to the tap root. We recently discovered a control pathway that regulates the activity of the sucrose transporter and, because of the transporter's role in loading the phloem, this regulatory system appears to control sucrose export from the leaf (Chiou and Bush 1998, Bush 1999). This was a very significant finding because loading the vascular system for sucrose export from the leaf determines how much sucrose is delivered to the tap root. Defining the biochemical and molecular steps involved in controlling sucrose delivery to the beet will allow us to develop new strategies for manipulating productivity.

RECENT PROGRESS:

Research this year focused on two areas: 1) experiments aimed at defining the key steps in sucrose-sensing regulatory pathway described above and 2) a biotech approach to express a hyperactive form of the sucrose transporter in the leaf phloem with the goal of increasing the amount of sucrose transported to the storage beet. Advances this year on sucrose sensing included making promoter luciferase plants that we can use to genetically dissect this response pathway. We have also developed a novel method to determine all the genes expressed in the plant's vascular cells. We are currently looking at those genes for candidates that play a role in sucrose sensing. For objective two, we are collaborating with Marc Lefebvre (Advanta Biotechnology) to make transgenic plants expressing the hyperactive transporter in the leaf phloem cells. We have constructed the expression vector and sent it to Marc for beet transformation. Once transgenic plants are produced, my lab will examine their growth and the impact of the hyperactive transporter on sucrose accumulation in the beet. We expect to receive those plants this summer. Five manuscripts have been published reporting these results and summarizing the status of the field (Bush and Coruzzi. 2000; Vaughn, Harrington, & Bush. 2002; Ransom-Hodgkins et al. 2003; Harrington and Bush. 2003, and Bush. 2004).

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